[redacted]

[redacted]

[redacted]

TOPOGRAPHIC STADIA SURVEYING

A MANUAL WITH REDUCTION TABLES
AND
A NEW TYPE OF REDUCTION DIAGRAM

BY

C. E. GRUNSKY, Eng.D.
Mem. Am. Soc. C.E.

18 ILLUSTRATIONS
and A FOLDING PLATE

NEW YORK
D. VAN NOSTRAND COMPANY
25 Park Place
1917

[redacted]

PREFACE

THE notes on Stadia Surveying, presented in this manual, were assembled a number of years ago. For the benefit of the surveyor who has occasion to use the telemeter they are now made available in printed form. The method of surveying herein described and the special type of diagram for the reduction of stadia notes, herewith supplied, have been found so satisfactory by the author, and by others who have tried them out, that he considers it a duty to give the profession the benefit of his experience.

C. E. GRUNSKY.

SAN FRANCISCO, CAL.,
June 1, 1917.

[redacted]

[redacted]

CONTENTS

STADIA SURVEYING

TOPOGRAPHIC STADIA SURVEYING

CHAPTER I

INTRODUCTION AND DEFINITIONS

Telescope Cross-hairs, Adjustable or Fixed. The telescope to be used in stadia work is equipped with three horizontal cross-hairs. The spacing of these cross-hairs may be either adjustable or fixed. For general use the fixed cross-hairs are preferred by most engineers and surveyors, though they are not without their disadvantages.

When the cross-hairs are adjustable frequent testing of the instrument rating may be necessary.

When the cross-hairs are fixed (this term being here use in the sense of permanent in their relative positions, *i.e.*, non-adjustable), the instrument's rating as reported by its maker should be carefully tested before any surveys requiring the limit of attainable accuracy are undertaken.

Tachymetry. Tachymetry is that branch of surveying which deals with the rapid measurement of distances, as, for instance, the determination of distance from an instrument by sighting with its telescope to a rod.

Telemeter. The term "telemeter" may be applied to any telescope equipped with cross-hairs for measuring distance, or equipped with micrometer screw or other device for accurate determination of the length of rod subtended by an angle of known amplitude. (Only the instruments equipped with cross-hairs are taken into consideration in this discussion, as these alone have come into general use in topographic surveying).

Stadia-rod or Telemeter-rod or " The Rod." These designations are applied to the rod which is used in connection with a telemeter for measuring distance. The rod may be equipped with targets, or, as is more common, it may be a self-reading rod; that is to say, a rod on whose face the subdivisions and repetitions of the distance unit are so plainly indicated by markings and figures that the instrument-man can read the rod without recourse to targets. The use of a target-rod is a refinement not justified by the accuracy attainable with a telemeter and need not, therefore, receive any special consideration.

Intercept. The intercept is the length of that portion of the rod, in stadia units, appearing between two cross-hairs, generally between the lower and the upper hairs.

The Anallatic Point. The anallatic point of any instrument is that point from which the distance to a rod which is read for distance is proportional to the intercept. For an ordinary telescope the anallatic point lies a principal focal length in front of the object glass.

The Telemeter Constant. This is a value to be determined for each telemeter. It is, for an ordinary telescope, the sum of the principal focal distance of the object-glass plus the length of the part of the telescope from the instrument's vertical axis to the object-glass. It is the distance (measured along the collimation axis of the telescope) of the anallatic point from the vertical axis of the instrument.

The Rod-reading. The rod-reading, as this expression is used in this manual, is one hundred times the intercept. Unless otherwise noted it is to be understood that an instrument rating of 100 is assumed. In other words one stadia unit on the rod is to be read and entered in the notes as 100.

The Sighting Point. The sighting point on the rod is that point on the rod to which the sight is taken for vertical angles. It is the point on the rod on which the middle cross-hair is set for the vertical angle.

The Rating Factor. The rating factor of any instrument is that factor by which, when sighting horizontally to a vertical rod, the intercept (read in any linear unit as for example in feet), must be multiplied to find the distance to the rod (in the same linear unit), from the anallatic point.

The Principal Focal Distance. The expression " principal focal distance " is the distance from a lens at which parallel rays of light passing through it are brought to a focus.

The Stadia Unit. The stadia unit is a rod increment of such length that one such unit will be intercepted, when sighting horizontally, for each 100 or 200 or other number of units (depending on the rating factor of the instrument), that the rod is distant from the anallatic point.

Theoretical Considerations. The object-glass of the

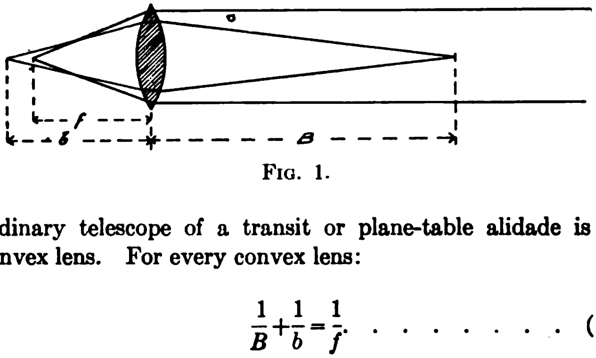

FIG. 1.

ordinary telescope of a transit or plane-table alidade is a convex lens. For every convex lens:

$$\frac{1}{B}+\frac{1}{b}=\frac{1}{f}. \qquad (1)$$

Here B is the distance from the lens to some object whose image appears on the opposite side of the lens at the distance b, and f is the principal focal distance of the lens.

A horizontal sight being assumed, let S, Fig. 2, represent the intercept on a rod and s the actual space between the cross-hairs. Then

$$b=B\frac{s}{S}. \qquad (2)$$

Combining (1) and (2)

$$\frac{1}{B}+\frac{S}{Bs}=\frac{1}{f};$$

$$S+s=\frac{Bs}{f};$$

$$B=f+f\frac{S}{s};$$

$$B-f=\frac{f}{s}S. \qquad \qquad (3)$$

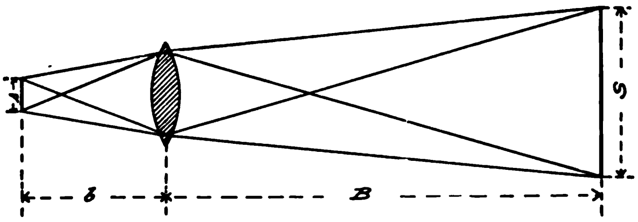

FIG. 2.

The value of s and the value of f for any telescope are constant, therefore, $\frac{f}{s}$ is a constant.

Make

$$\frac{f}{s}=K,$$

Then

$$B-f=KS. \qquad \qquad (4)$$

The distance $B-f$, Fig. 3, is proportional to the intercept S.

The relation between $B-f$, S, s and f expressed in Eq. (3) appears also from the optical principle illustrated in Fig. 3.

The Porro Telescope. It is practicable to construct a telescope in which the anallatic point will coincide with the vertical axis of the instrument. This fact was first demonstrated by an Italian officer, Mr. Porro, who, in 1823, con-

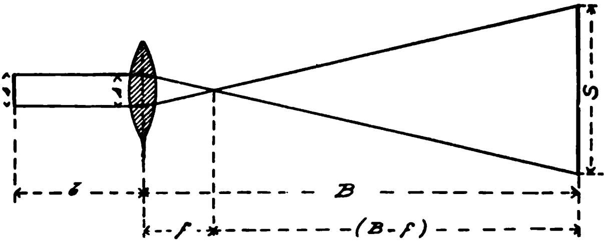

FIG. 3.

structed and described a telescope in which lenses were so combined that all rod-readings were proportional to the distances from the center of the instrument. How this was done will appear by reference to Fig. 4. The object-glass O and the auxiliary lens O' are so placed that the vertical axis

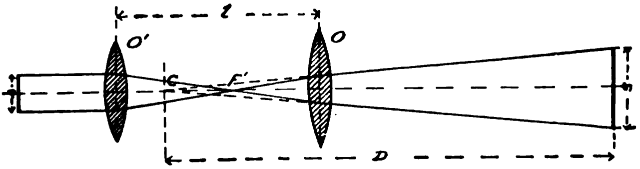

FIG. 4.

of the instrument, at C, is between them. The object-glass O has a longer focal distance than that of the ordinary telescope. If the construction is such that the points C and F' are conjugate foci for the lens O and the two lenses are rigidly connected, the angle at C will be constant. In other words, the intercept S will be proportional to the distance D, Referring to this type of instrument, which has not come into use in this country, Mr. A. Lietz says:*

"Since stadia measurements originate from the outer focus of the objective lens, and not from the center of the instrument, it becomes somewhat troublesome to apply a correction therefor on inclined sights, for, since the corrections remain constant for any distance and vary with the angle of inclination only, it is not practical to incorporate them directly into the tabular values employed in reducing stadia observations. Such tables are usually augmented by placing the corrections due to what is generally termed the constant *c* at the bottom thereof. To overcome this difficulty, and to make every reading date directly from the center of the instrument, the Italian Porro invented a method in 1823, which is now beginning to be better known. This method has been frequently discussed. The Journal of the Franklin Institute contains an article in a number as far back as 1868. The *Engineering News* of November 8, 1890, has a short discussion by one of our best writers on these subjects, Prof. J. B. Johnson, of Washington University, St. Louis.

"A convex lens of required focal length is inserted between the objective and the eyepiece, which transfers the anallatic point to the occupied center. Theoretically this is necessary, for the observed vertical angles have their common vertex in the center of the arc, or horizontal axis of the telescope; while the vertex of the diastimometric angle lies outside of the objective, a distance of 14 ins. from the center of the instrument in the ordinary large transit. This would cause slight errors in vertical angle and distance, which disappear in the Porro telescope.

"There are very substantial reasons, however, why this anallatic lens has not found a more general application in modern surveying instruments, for it is not a new thing with which we are dealing, but a principle that was known and used over half a century ago; and these reasons will now be briefly considered.

"By inserting an additional lens the equivalent focal length of the objective is considerably decreased, and the power and capacity are thereby correspondingly lessened. To exemplify this, reference is made to an actual test of which the results were accessible to me. In this case the focal length of the objective equaled 13½ ins., that of the inserted lens 5 ins. and the distance between them 9⅜ ins. The equivalent focal length of the combination was, therefore, 7⅜ ins. The image of the system lay 2¼ ins. behind the anallatic lens, and its distance from the objective, therefore, 11⅝ ins. Here we notice

* Journal Assoc. Engrg. Socs., Vol. 19, 1897, p. 256 et seq.

that the available focal length has been shortened by the lens combination 4¼ ins., which is a direct loss of nearly 37%. An ordinary telescope with a focus of 11¾ ins., possessing an eyepiece with one of ½ in., would have a power of 23, while the Porro telescope under similar conditions shows only 15, indicating the same percentage of loss in power. There is, however, a slight gain in brightness with the same aperture of objectives, for the reason that the admitted light is concentrated in a smaller space. In order to make up for the loss in power, due to the anallatic lens, a more powerful eyepiece must be made use of. One with an equivalent focal length of $\frac{5}{16}$ in. would about compensate the 37% loss, but the brightness of the image would not then be quite up to that of the ordinary telescope, since the middle lens will cause a slight loss of light by reason of reflection and absorption. This, however, might again be rectified by giving the objective a somewhat larger aperture.

"While it is readily seen that a Porro telescope might be constructed fully up to the capacity of our ordinary transit telescope, it is also apparent that much greater care and refinement would have to be resorted to to reach it, for it is very important that the entire mechanical work should be perfectly in harmony with the greater optical requirements. The tubes must be absolutely straight, the axes of the lenses must be identical and their principal planes normal thereto. Greater care must be exercised in the construction of the objective, it being necessary to correct therein for the aberration due to sphericity and achromatism of the anallatic—which is usually a simple convex lens—if we would retain a clear and distinct image.

"It is a problem for the instrument maker to construct the Porro telescope so that there shall be no complicated parts, and no excess of cost to speak against it. The additional lens, whose focal distance depends upon the length of the telescope and the location of the center of the instrument, is placed in front of and not too far from the cross-hair diaphragm. Its distance from the objective must necessarily remain constant, and any motion of the latter in the tube must be made with the middle lens also. The lenses must move together.

"It might be a more advantageous construction to adopt the movable eyepiece, and to focus by shifting the cross-hair diaphragm in connection therewith.

"This lens combination has one peculiar advantage that must not be left unmentioned, which is that it requires but a very small telescopic slide movement to focus from long to short distances and vice versa. A range of half an inch may be sufficient to cover all the required lengths of sight.

"In building the tube, provision must also be made for removing the inner lens in order to clean it, which would pr be frequently required. The arrangements for this purpose n so contrived that the lens may be replaced in its proper positi accurately adjusted to the required optical conditions.

"Every feature goes to show that the mechanical work of telescope must be of the highest order, if it shall meet the de made upon it. With the cheaper grade of surveying instrum Porro telescope is an impossibility.

"Granted that we have a Porro telescope fully up to the and capacity of that of the simpler construction, there are th stant disadvantages of using a powerful microscope, which be more or less fatiguing to the eyes of the observer; and the ac lation of dust on the inner lens, a difficulty that may lead to c erable trouble and annoyance. These reasons have been mor sufficient to prevent the anallatic telescope from being ger introduced and practically used. It is granted, however, tha precise instrument, it is perfectly within the reach of the c and mechanical arts to build one that shall fully accompli translation of the anallatic point to the center of the instrume

CHAPTER II

THE STADIA FORMULA

Derivation of Formula. The value $(B-f)$ in Eq. (4), for any ordinary telescope arranged as a telemeter is, as has been shown, proportional to the intercept S on a rod held vertically. In other words, sighting horizontally, the parallel cross-hairs of the telescope will intercept a space on a rod proportional to the distance at which the rod is held

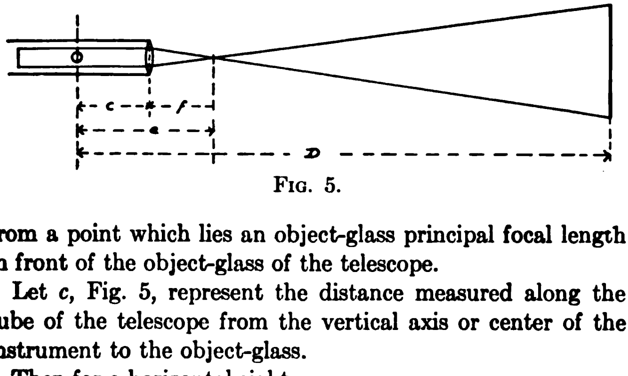

FIG. 5.

from a point which lies an object-glass principal focal length in front of the object-glass of the telescope.

Let c, Fig. 5, represent the distance measured along the tube of the telescope from the vertical axis or center of the instrument to the object-glass.

Then for a horizontal sight

$$D=B+c; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

or

$$D=(B-f)+(c+f). \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

From (4)

$$D=Ks+(c+f). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Calling

$$c+f=e, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

which is allowable because the value c, being affected only by the movement of the object-glass in focusing upon the rod is for practical purposes to be regarded as a constant, Eq. (7) becomes

$$D=e+KS. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

This is the fundamental formula. K is called the ***rating factor*** and e may for convenience be called the ***instrument constant.***

The values of c and of f, and, therefore, the value of e, can always be directly measured with sufficient precision; f in the instrument of the ordinary type with single objective is the length of that portion of the telescope tube between the objective glass and the cross-hairs, when the telescope has been focused upon a distant object. The value of c may be determined also by measurement when the telescope is focused upon some object about 50 ft. distant.

Determination of the Rating Factor. When a telescope has fixed cross-hairs and the value of c has been ascertained the instrument's rating factor is determined as follows:

Measure from the vertical axis of the instrument as follows:

To point P_1 at $(100+e)$ ft.;
To point P_2 at $(200+e)$ ft.;
To point P_3 at $(300+e)$ ft.·
etc. etc.
To point, P_{10} at $(1000+e)$ ft.

The selected ground for such a determination must be such that all of the readings can be made with a horizontal telescope otherwise the rod must be held normal to each line of sight and the distance measured on the ground must be parallel with this line of sight.

The rod being held at each of the ten points there will be obtained ten rod readings (each foot on the rod being read as 100 ft.). These readings are now divided in their order by 1, 2, by 3, etc., by 10. Each quotient will be an observed value of the instrument's rating-factor. The mean of the observed values is to be accepted as the value of K. No individual observation should vary more than 0.2% from the mean.

The stadia unit is then $\frac{100}{K}$ ft.

For example: Suppose $K=80$ then $\frac{100}{80}=1.25$ ft., the stadia unit. If now a rod based on the subdivision of 1.25 ft. instead of 1 ft. as the unit be prepared for use with the telescope whose stadia unit is 1.25, then each such unit may be read as 100 ft.

Calling the stadia unit u, its value is

$$u=\frac{100}{K}; \quad \ldots \ldots \ldots \quad (10)$$

but

$$D=e+KS; \quad \ldots \ldots \ldots \quad (9)$$

therefore

$$D=e+100\frac{S}{u}. \quad \ldots \ldots \ldots \quad (11)$$

The *distance* in feet, in other words, will be the instrument constant plus 100 times the *intercept measured in stadia units.*

Whenever a rod has a stadia-unit other than one foot, some scheme of rod subdivision and marking should be used that will enable an easy identification of the rod, which is in this event to be used only with a particular instrument, and only for stadia and vertical angle work—not for any ordinary leveling.

When the cross-hairs of the telescope are adjustable they can be set so that the rating of the instrument will be convenient, usually 1 to 100.

To adjust the cross-hairs measure from the center of the instrument to a distance about equal to the average length of a sight making the same some multiple of 100 ft. increased by the instrument constant as, for instance $(400+e)$ ft. The cross-hairs are now so adjusted that the intercept between the lower and the upper hairs when sighting with a horizontal telescope will be exactly 4 ft. and that the middle cross-hair will exactly bisect this intercept. The rating of the instrument is thus made 1 to 100. If so convenient a rating factor as 100 is not practical the cross-hairs may, of course, be so adjusted that the intercept will have to be multiplied by some other round number—such as 50, 150 or 200—to make the product 400.

After the cross-hairs have been adjusted with the rod at some such distance as $(400+e)$, or $(500+e)$, or $(600+e)$ ft., readings should be taken at other measured distances, as for example at one-half the distance first selected and at a point at twice this distance, in order to give a check upon the accuracy to be expected. The error in an individual sight for adjustment under assumed favorable atmospheric conditions, should not exceed 0.2%, if the instrument is intended for use in ordinary topographic surveying.

It may be repeated that, for the instrument with fixed cross-hairs, either the rating factor must be determined, as explained, and used in estimating distances from readings on a rod with the measuring unit (one foot), as the subdivision unit, or in the manner already described the stadia unit is calculated from observations and a special rod is constructed for use with that instrument only. The latter is rarely a desirable procedure.

General Formulas for Inclined Sights. When the transit, or the alidade of the plane-table are used to measure both distance and difference in elevation, the rod may be held either normal to the line of sight or vertical. In the first case the length of the inclined line from the instrument to the sighting point on the rod is measured. In the second case a reading is obtained from which the horizontal distance to the rod and the difference in elevation may be calculated. The advantages, for all ordinary surveying, of the second method, as illustrated in Fig. 6, are so pronounced that it is not necessary to discuss the use of the inclined rod.

In Fig. 6 the intercept on a rod held vertically at the point P is S. The vertical angle, when the middle cross-hair is set on the sighting-point P', is α.

It is to be remembered, as already stated, that throughout this manual, except when otherwise noted, instruments rated 1 to 100 are referred to. For such instruments the

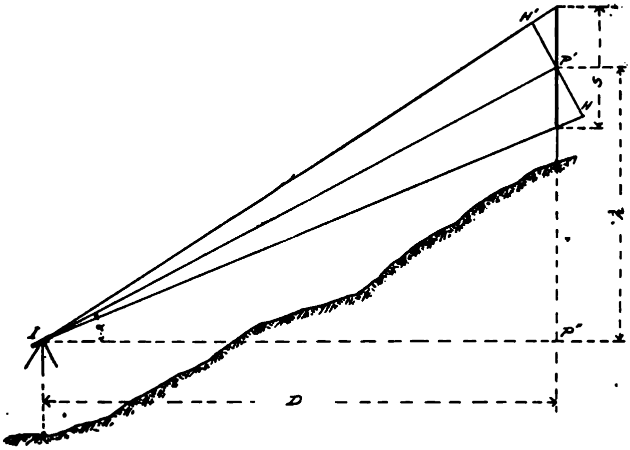

FIG. 6.

rod-reading, as entered in the notes of the surveyor, will be 100 S. When instruments have some other rating the value KS may be substituted for the rod-reading (*i.e.*, for 100 S.)

Referring again to Fig. 6, it will be seen that if the rod had been held through the point P′ normal to the axis of the telescope, the intercept would have been HH', instead of S. The length of HH' establishes the length of the inclined line IP', and the line IP' together with the vertical angle

α enables a calculation of the horizontal distance D and of the difference of elevation h to be made.

$$HH' = S \cos \alpha \text{ (very nearly)}; \quad \ldots \quad (12)$$

$$IP' = 100\, S \cos \alpha + e; \quad \ldots \quad (13)$$

$$D = (100\, S \cos \alpha + e) \cos \alpha; \quad \ldots \quad (14)$$

and

$$h = (100\, S \cos \alpha + e) \sin \alpha. \quad \ldots \quad (15)$$

Calling the rod reading

$$100\, S = r; \quad \ldots \quad (16)$$

will make

$$D = r \cos^2 \alpha + e \cos \alpha; \quad \ldots \quad (17)$$

$$h = r \sin \alpha \cos \alpha + e \sin \alpha; \quad \ldots \quad (18)$$

which is

$$h = r(\tfrac{1}{2} \sin 2\alpha) + e \sin \alpha. \quad \ldots \quad (19)$$

These are the formulas in ordinary and in general use for the determination of distance and difference in elevation with a stadia instrument. They are not strictly correct, because Eq. (12) is not mathematically correct. The line HH' normal to the collimation axis of the telescope is not normal to the two lines IH and IH', between which the intercept lies. These lines in the case of an instrument rated at 100 enclose an angle of about 34′. Each of these lines departs from the line of sight by about 17′. It follows that while HP' is exactly equal to $H'P'$ the intercept S is not exactly bisected by the middle cross-hair, there being in the small triangle BHP' and $B'H'P'$ (see Fig. 7) an acute angle at H of about 89° 43′, while at H' in the other small triangle the angle is obtuse, 90° 17′.

It can readily be shown that the error made in accepting Eq. (12) is so small that it is negligible. In order that this may become apparent the following is presented. Referring to Fig. 7, draw the lines HA and $H'A'$ perpendicular to HH' then

$$HA = H'A' = \frac{S}{2} \sin \alpha. \quad . \quad . \quad . \quad . \quad . \quad (20)$$

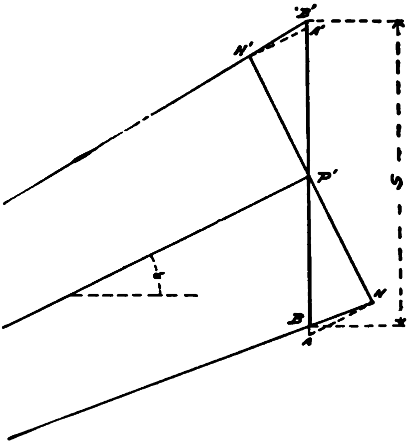

FIG. 7.

In the triangle HAB the angles will be, for an instrument rated at 100:

At H, 17′;
At A, $90° - \alpha$;
At B, $90° + \alpha - 17'$.

In the triangle $H'A'B'$ the angles will be

At H', 17′;
At A', $90° + \alpha$;
At B', $90° - \alpha - 17'$.

Therefore

$$AB = \frac{S}{2} \sin \alpha \frac{\sin 17'}{\sin (89° \, 43' + \alpha)}; \quad . \quad . \quad . \quad (21)$$

$$A'B' = \frac{S}{2} \sin \alpha \frac{\sin 17'}{\sin (89° 43' - \alpha)}; \quad . \quad . \quad . \quad (22)$$

and because

$$HH' = (S - A'B' + AB) \cos \alpha; \quad . \quad . \quad . \quad . \quad (23)$$

$$HH' = S \cos \alpha \left[1 - \frac{\sin \alpha \sin 17'}{2}\left(\frac{1}{\sin (89°43' - \alpha)} - \frac{1}{\sin (89°43' + \alpha)}\right)\right]. \quad (24)$$

and

$$D' = 100S \cos^2 \alpha \left[1 - \frac{\sin \alpha \sin 17'}{2}\left(\frac{1}{\sin (89°43' - \alpha)} - \frac{1}{\sin (89°43' + \alpha)}\right)\right] + e \cos \alpha. \quad . \quad (25)$$

The error that results in using formula (14) or (17) in place of formula (25) will be

$$D - D' = 100S \cos^2 \alpha \left[\frac{\sin \alpha \sin 17'}{2}\left(\frac{1}{\sin (89°43' - \alpha)} - \frac{1}{\sin (89°43' + \alpha)}\right)\right]. \quad (26)$$

Based on this equation it appears that the inaccuracy of Eq. (17) is as follows:

For

$\alpha = 10°$ the error will be only .00007%;

$\alpha = 20°$ the error will be only .0003%;

$\alpha = 30°$ the error will be only .0008%;

$\alpha = 45°$ the error will be only .0025%.

These errors are, as already stated, too small to be taken into account.

Approximation Formulas. The value of e is generally small. It will rarely exceed 2 ft. and will generally be nearer 1 ft. This being the case there will be only a slight error introduced if in formulas (17) and (18) the value e be replaced by $e \cos \alpha$. This substitution is certainly allowable in all ordinary topographic surveying operations, in which distances are required only to the nearest foot.

With this modification the formulas (17) and (18) become

$$D = (r + e)\cos^2 \alpha \text{ (approximate)}; \quad \ldots \quad (27)$$

$$h = (r + e)\sin \alpha \cos \alpha \text{ (approximate)}. \quad \ldots \quad (28)$$

In this form the formulas are very convenient.

The expressions $(r+e)\cos^2 \alpha$ and $(r+e)\sin \alpha \cos \alpha$ in these equations and the expressions $r \cos^2 \alpha$ and $r \sin \alpha \cos \alpha$ in Eq. (17) and (18) are such that they can conveniently be obtained from diagrams, as will hereinafter be explained.

The practice of disregarding entirely the distance increment $e \cos \alpha$ in formula (17), and the elevation increment $e \sin \alpha$ in formula (18) can not be endorsed. Although, as is well known, the error of the individual moderately long sight is frequently in excess of the value of e, the effect of ignoring the correction altogether would be cumulative, a source of error which is not allowable when locating primary or secondary stations.

There is less objection to doing this when side shots for ground elevation only are involved. In this case the author's practice has always been to enter the reduction diagram, hereinafter described, with a value $(r+1)$. One foot is a sufficiently close approximation of the value of e for all ordinary surveying instruments.

For unimportant side shots, such as shots for elevation of the ground, the following approximations can therefore be recommended:

$$D = (r + 1)\cos^2 \alpha; \quad \ldots \quad (29)$$

$$h = (r + 1)\sin \alpha \cos \alpha. \quad \ldots \quad (30)$$

Suggestions Relating to the Use of the Formulas. In reducing the field observations it will be well to be guided by the following suggestions:

1. Use the correct formulas (17) and (18) in making surveys which require the greatest attainable accuracy.

2. Use the approximation formulas (27) and (28) and stadia reduction tables for foresights and backsights and for sights to reference points.

3. Use the approximation formulas (27) and (28) or (29) and (30) and a slide rule or such diagrams as accompany this manual for all ground heights and general topography.

In order that the accuracy attainable by use of the approximation formulas (27) and (28) may be correctly gaged, it is to be stated that their use introduces errors as follows:

When $e = 1.5$ ft. the error in distance will be less than 0.1 ft. for all vertical angles less than 20°; it will be −0.2 ft. for a vertical angle of 30°, and −0.3 ft. for a vertical angle of 45°. The error in elevation will be less than 0.1 ft. for all vertical angles less than 30° and it will be −0.3 ft. for a vertical angle of 45°.

For values of e other than 1.5 ft. the errors can readily be approximated from the foregoing, as they increase or decrease proportionately with e.

CHAPTER III

DIAGRAMS FOR THE REDUCTION OF STADIA MEASUREMENTS

Diagrammatic Solution of Stadia Formulas. The following considerations have led to the preparation of diagrams for the determination of values for the expressions $r \cos^2 \alpha$ and $r \sin \alpha \cos \alpha$ in Eq. (17) and (18), $(r+e) \cos^2 \alpha$ and $(r+e) \sin \alpha \cos \alpha$ in the approximation formulas (27) and (28) and

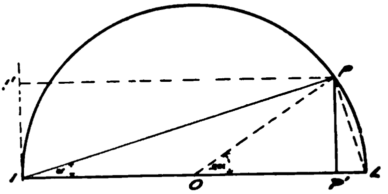

FIG. 8.

for the expressions $(r+1) \cos^2 \alpha$ and $(r+1) \sin \alpha \cos \alpha$ in the approximation formulas (29) and (30).

In any circle whose radius is OP, Fig. 8, there will be

$$IP = IL \cos \alpha;$$

$$IP' = IL \cos^2 \alpha;$$

$$PL = IL \sin \alpha;$$

$$PP' = IL \sin \alpha \cos \alpha.$$

If IL, the diameter of the circle be made equal to r or to $(r+e)$ or to $(r+1)$, according to the formulas to be used,

[redacted]

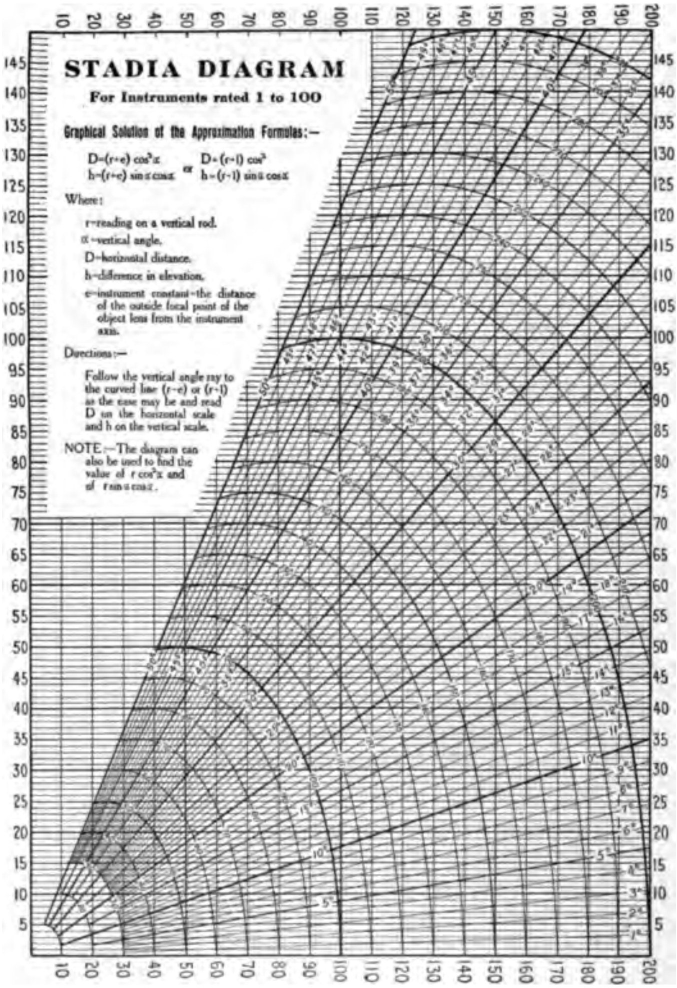

FIG. 9.

the line IP' will represent the distance increment and PP' the difference of elevation increment in the above formulas.

If, now, for all possible values of r, or of $(r+e)$, or of $(r+1)$ as the case may be, a series of semicircles be drawn all having a common point I, each circle will be the focus of the points P determined by all possible values of the vertical angle and a value of r, or of $(r+e)$, or of $(r+1)$, equal to the diameter of each circle. In other words, for any vertical angle α the limiting side line of the angle, or the angle ray, will cut the circle at a point P such that the horizontal line IP' or $I'P$ will be the value as the case may be of $r \cos^2 \alpha$, or of $(r+e) \cos^2 \alpha$, or of $(r+1) \cos^2 \alpha$, and that PP' will be the value of $r \sin \alpha \cos \alpha$, or of $(r+e) \sin \alpha \cos \alpha$, or of $(r+1) \sin \alpha \cos \alpha$.

Semicircles with diameters increasing by regular amounts 1 ft., or 2 ft., or 5 ft., or 10 ft., according to scale, and horizontal lines forming a scale by which to read off difference in elevation and vertical lines by which to read off distance, complete the diagram.

To secure accuracy in scaling difference in elevation the unit of the vertical scale may be made larger than the unit of the horizontal scale. The semicircles will then be ellipses. According to the scales adopted any reasonable degree of accuracy can be attained. (See Fig. 9.)

For ordinary topographic surveying the stadia diagram accompanying this manual will be found adequate to fill every requirement. This diagram is so arranged that both difference in elevation and correct horizontal distance can be read at the same point. The diagram has been drawn, in the main, to logarithmic scales in order that, for practically all distances the relative accuracy of results obtained by its use will be substantially the same. The distances shown on the diagram are from 100 to 1000 feet. They might have been called 10 to 100 or 1 to 10 feet with a corresponding modification of the difference in elevation. The scale from

100 to 1000 feet was adopted because the largest number of sights will ordinarily fall between these limits.

The curved lines in the diagram represent all possible values of r, of $r+e$, or of $r+1$.

In using the diagram the same care must be exercised in placing the decimal point correctly as in the case of slide rule work. It is to be noted that in any region in which orographic features are pronounced it would be useless to attempt to measure elevations with greater precision than to the nearest foot. They may, of course, be read from the diagram and entered in the notes to tenths, but should in such case appear on the map without fractional feet.

The Diagram Furnished with this Manual. The diagram for the reduction of stadia notes which accompanies this manual is prepared specifically as a graphic solution at one operation of the approximation formulas.

$$D=(r+e)\cos^2\alpha; \quad . \quad . \quad . \quad . \quad . \quad (27)$$

and

$$h=(r+e)\sin\alpha\cos\alpha. \quad . \quad . \quad . \quad (28)$$

But the diagram may also be used in ascertaining the values of $r\cos^2\alpha$ and $r\sin\alpha\cos\alpha$ in the correct formulas Eq. (17) and (18) and for the approximation of $(r+1)\cos^2\alpha$ and of $(r+1)\sin\alpha\cos\alpha$ in the approximation formulas (29) and (30). As the formulas (17) and (18) need only be used for sights to turning points and on surveys requiring more than ordinary precision, it would seem advisable to give preference to reduction tables whenever such approximation formulas as (27) and (28) or (29) and (30) will not serve.

To Use the Diagram. Follow the ray which corresponds to the angle α of elevation or depression to its intersection with the curved line which corresponds to the value $(r+e)$ in formulas (27) and (28). Holding a needle point at the intersection thus determined read off on the vertical lines the horizontal distance D, that is $(r+e)\cos^2\alpha$, and on the horizontal lines the difference in elevation h, that is $(r+e) \sin \alpha \cos \alpha$.

Thus when the approximation formulas are to be used, the diagram gives at once the distance and the difference in elevation for any rod-readings and any vertical angles within their scope. Distance should be read to the nearest foot and difference in elevation to the nearest tenth of a foot.

When points are located by the intersection of sights from two instrument stations, the horizontal distances from each of these two stations are scaled from the map. The diagram is now entered with each of these distances and needle points are placed at the intersection of these distances with the corresponding angle rays of the measured angles of elevation or depression. If the same difference of elevation is not indicated by both needle points the mean value should be recorded.

CHAPTER IV

THE SLIDE-RULE AS AN AID IN REDUCING STADIA NOTES

Modification of Formulas for Slide-rule Work. It is not always convenient to use a diagram in reducing rod-readings and vertical angles to distance and elevation difference. This is particularly true for plane-table work which requires that the reduction be made in the field. In such cases slide-rules may be used to advantage. Special slide-rules are made for the purpose. These need not receive any special notice. But the ordinary slide-rule can be made a convenient aid as will now be shown.

Formulas (17) $D = r \cos^2 \alpha + e \cos \alpha$;

(18) $h = r \sin \alpha \cos \alpha + e \sin \alpha$;

and (27) $D = (r + e) \cos^2 \alpha$ (approximate);

(28) $h = (r + e) \sin \alpha \cos \alpha$ (approximate);

can be made convenient for solution with the slide-rule by substituting for $\sin \alpha \cos \alpha$ the trigonometric equivalent

$$\sin \alpha \cos \alpha = \tfrac{1}{2} \sin 2\alpha. \quad . \quad . \quad . \quad . \quad (31)$$

For work with the slide-rule only the approximation formulas (27) and (28) or (29) and (30) should be used.

In combination with (31) the Eqs. (27) and (28) will become:

$$D = (r + e)\cos^2 \alpha; \quad . \quad . \quad . \quad . \quad . \quad (27)$$

$$h = \frac{r + e}{2} \sin 2\alpha.$$

Both of these equations or similar equations containing the factor $(r+1)$ are readily solved with the ordinary slide-rule.

CHAPTER V

METHODS OF STADIA SURVEYING

Stadia Surveys Without the Use of the Magnetic Needle. When the plane-table or transit are oriented without the use of a magnetic needle, the instrument is to be set up over a starting point of known position and elevation. The height *i* of the telescope above the bench-mark or station-plug is measured and the table or transit are oriented. The first orientation is adapted to the shape of the area to be covered or to other considerations. It may, of course, be based on a north point determination. At all subsequent settings the plane-table or the lower plate of the transit, as the case may be, must be brought into a position parallel with the first setting. To accomplish this in the case of the transit, after setting the vernier at the azimuth which was read at the last station (when sighting toward the new station), and reversing the telescope, a sight is taken back toward the last station, whereby the lower plate of the transit is brought into the desired position. In the case of the plane-table the operation is similar, the ruler of the alidade being reversed along the last station sight.

At each setting the height *i* of the telescope above the station plug is measured. This height determines the elevation of the telescope the " height of instrument " in case this should be required. Ordinarily, this will not be required, all sights being taken for vertical angles to the point *i* on the rod as determined for each instrument setting. Differences in elevation as then determined, regardless of the value of *i*, are thereupon applied directly to the plug elevation of the instrument station. Only when level sights are taken and the rod is read direct for elevation will it be necessary to apply the readings to the height of instrument, which is, of course, the elevation of the station plug plus *i*.

The rule should be carefully observed to *let the last sight recorded at any station be the sight to the next station to be occupied.*

From each station as occupied there will first be the orientation of the transit or plane-table. In sighting back upon the last station occupied the rod should again be read for distance and the vertical angle should be noted. The survey is thus checked. The mean of the two observations, if there be no palpable error, should be used in determining position and elevation of the new station.

As a variant of the foregoing the transit may be used at each station to determine the azimuth of all sights taken in their relation to the backsight. In this case the vernier is set at zero when taking the backsight for orientation.

Each instrument station should be at such distance from the preceding—topographic features being considered—that it will command a fair amount of new territory. A foresight of the length of ordinary sights for topographic points would place the new station at the margin of the territory already commanded. In some cases it may be advisable simply to make the foresight as long as consistent with the accuracy required. In other cases it may be of advantage to treat alternate stations as secondary stations using them only for the purpose of locating the next primary station farther on.

Referring to stadia surveys, Noble and Casgrain, in the introduction to their tables for horizontal distance and difference of level,* say: "The height of instrument can be determined from the backsight, or the instrument can be set over a point whose height has been determined and the

* A. Noble and W. T. Casgrain. Tables for Horizontal Distance and Difference of Level. Eng. News Pub. Co., 1902.

height of the telescope above it is measured directly by a light graduated rod carried for the purpose. The latter is the usual method."

Stadia Surveys with the Use of the Magnetic Needle. When the magnetic needle (or a solar compass) is used in orienting the transit or the plane-table, or in determining the azimuth of the sights taken with the transit, a different method of surveying is made possible. The intermediate or secondary stations can be treated as turning-points.

The instrument is not set up at all at the secondary stations. But, in this case, the double sighting between stations is no

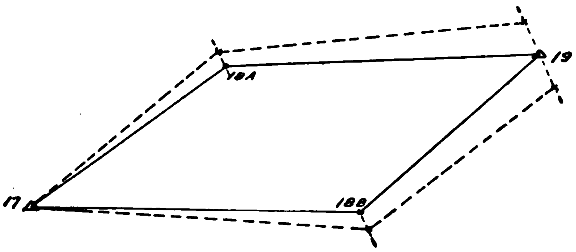

FIG. 10.

longer possible and recourse should be had to some other method of checking the observations. Probably the best method of accomplishing this is by using two intermediate stations, preferably so selected that the angle between the two foresights to these stations will be at least 30°. As all stadia work should be done with two or more rodmen there is usually no difficulty in adopting this double-turning-point method. Two locations and two elevations of each primary station will thus be obtained. Barring gross errors, the mean of the elevations and of the positions of the new instrument station thus determined should be accepted. (Corrections can be carried back, if desired, to the two secondary stations.)

Fig. 10 illustrates a set of sights of this kind. The broken lines show the sights as taken; the full lines as they will appear when corrected.

The method of keeping notes for a transit survey by the double-turning-point method is illustrated on page 40.

CHAPTER VI

PRACTICAL SUGGESTIONS

Departures from Ordinary Practice. The author has found several departures from the ordinary methods of stadia surveying advantageous and recommends them to those who have occasion to use the stadia. These departures, including some modifications of methods already alluded to, relate:

1. To the type of rod.
2. To the elimination from the notes of the height of the telescope above a station plug.
3. To the liberal use of the magnetic needle.
4. To the method of keeping field notes.
5. To the use of approximation formulas.
6. To the use of convenient stadia reduction diagrams.

The Stadia Rod. The rod which is here described was designed and its markings were devised about 1880 in the office of the State Engineer * of California. No one will be surprised or misled when the author, under whose supervision the first rod of the kind was made, states that he has found no other self-reading rod equally satisfactory for general use. The rod is presented on its merits, without prejudice to other self-reading rods of which many more or less satisfactory types are on the market.

The rod is shown in Figs. 11 to 16. It is a folding rod, being cut midway of its length, so that, when folded, the painted face of the rod will be protected against injury.

* Wm. Hammond Hall was at that time the State Engineer of California.

Stiffness when extended is secured by means of a light board, Fig. 11, with projecting overlapping edges. The hinges are relieved of all strain by this arrangement.

Into the back of the stiffening board are set two small plates of iron with round holes through which, and through

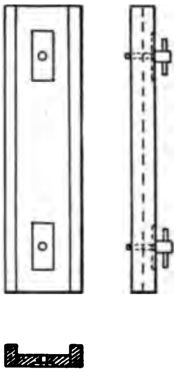

FIG. 11.—The stiffening board.

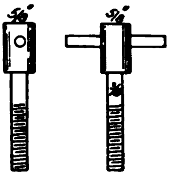

FIG 12.

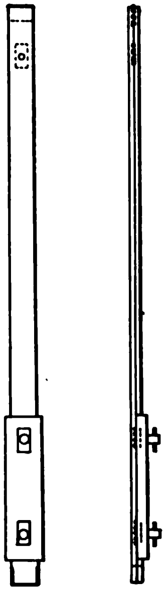

FIG. 13.—The folded rod.

the board and through the rod, thumb-screws pass to similar plates with threaded holes in the face of the rod.

The type of thumb-screw to which preference has been given by the author was turned from a round bar of iron, as shown in Fig. 12. A small bar through the head of the screw gives ample leverage for setting the screws tight, which is a matter of no small importance. The rod when extended

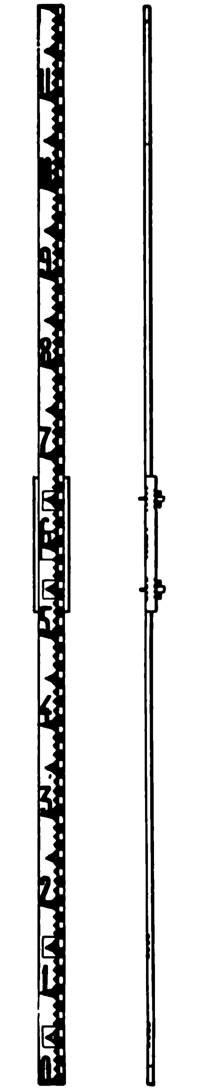

Fig. 14.—*Stadia rod.*

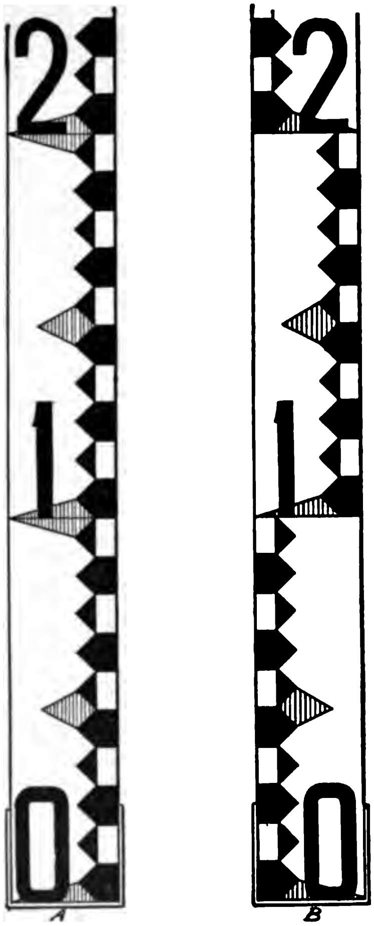

Fig. 15.—Two types of rod. *A*. For ordinary use. *B*. For long sights.

should have no lost motion at the central joint. Thumb-screws of the type described, cut from about ⅝ in. iron, will stand much rough handling.

When folded up the stiffening board is shifted to near the end of the rod, Fig. 13, where there are holes for the free passage of the thumb-screws through one leaf of the folded rod into the threaded holes of two more small iron plates set in the opposing face of the other leaf. The thumb-screws here not only hold the stiffening board securely in place, but clamp the two leaves of the rod, so that there can be no sliding of face against face. In its folded condition the rod is exceptionally well protected and will stand much handling without injury.

The preferred length has always been 11 or 12 ft. but shorter or longer rods may be found convenient. The folded length is just one-half of the full rod length. The top and bottom of the rod should be shod with strips of iron, though in the case of the top, lighter iron than in the case of the bottom may be used.

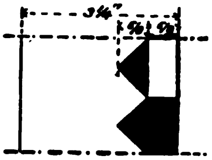

FIG. 16.—A two-tenth rod increment.

The width of the rod should be at least 3¼ in. It may, at pleasure and to advantage, be made somewhat wider.

Any type of lettering and subdivision may now be used, but one which is not likely ever to be abandoned if once tried, particularly by those who delight in using home-made rods, is the one shown in Figs. 14, 15, and 16. When the rod is wider than 3¼ ins. the spaces marked ⅝ in. Fig. 16, should be increased somewhat. A longer oblique line than shown, for the interpolation of hundredths of a foot, will be found advantageous.

The reading is to the nearest hundredth of a foot along the oblique lines of the black triangle. *The figures cut by the cross-hair are always read;* they stand on the footmarks.

The black rectangle of the odd tenths backed by a black triangle, together with the superimposed triangle of the next even tenth make a characteristic design, Fig. 16, which helps the eye to mount from point to point with certainty by two-tenth intervals. The tops of the figures are always three-tenths points. The five-tenth points are indicated by red diamond-shaped marks and the full foot by similar elongated red spear-heads, or half spear-heads, extending across the face of the rod.

With telescopes of the ordinary power a rod of this kind with 3¼ in. face is good for all distances ordinarily entering into stadia work. When sights exceeding 600 ft. are frequent, it will be found convenient to use a rod with the subdivisions of the feet alternately at the left and at the right edge of the rod, as shown in Fig. 15.

Any sign painter can paint such a rod. It can be marked in a few minutes. On the white painted surface, after drawing the longitudinal line at the base of the triangles, the foot marks are to be laid off with care, using a tested steel tape. That the foot marks should be correct is of prime importance. The zero point of the rod should preferably be at the top edge of the metal shoe, not at its bottom, which is subject to wear. Using a pattern cut from a sheet of tin or other convenient material, one foot long, the oblique limiting lines of all the black triangles can be drawn practically with a continuous stroke. A stencil may be used in outlining the figures. The red diamonds may now be painted, then all the black on the rod. Sharp outlines of the markings can be secured by using a ruling pen before filling in with the brush.

The red diamonds are convenient identification points for short sights. Colors can not be distinguished at long distances, except when light is very favorable.*

* A stadia rod in substantial agreement with the foregoing specifications has been put on the market by the A. Lietz Co., Instrument Manufacturers, San Francisco, Cal.

For work requiring very long sights crosspieces at several points of the rod, projecting beyond its sides, and a slender extension with similar crosspieces, have repeatedly been found to be of great help.

The wood used for such a rod should be straight-grain and well seasoned. According to the character of the wood chosen, the thickness of the rod and of the stiffening board may range from about $\frac{5}{8}$ in. to $\frac{7}{8}$ in.

When the meter is the distance unit instead of the foot, the markings on the rod should be as shown in Fig. 17. Here again the eye recognizes at a glance the even and odd subdivisions. The readings can be made to the nearest tenth of a meter. Such a rod is serviceable for precise leveling.

FIG. 17.—A metric stadia rod.

The Elimination of the Height of the Telescope above the Instrument Station Plug. The ordinary method of doing stadia work requires that sights be taken for vertical angles to some point on the rod determined by the height i of the telescope above the station plug. It will be found much more convenient to disregard the height of the telescope above the instrument point altogether,* and to take all sights to the 5-ft. mark or to some other selected foot mark which is at about the ordinary height of the telescope above the ground. That this height need not be the exact height of the telescope above the ground can readily be seen and will be better understood by reference to the

* Dr. W. Jordan: Vermessungskunde, p. 630.

diagram Fig. 18. The difference in elevation between the point *B* in this diagram and the point *C* is entirely independent of the height of the tripod at the point *A*. It can be calculated from the two sights *AB'* and *AC'*. The height of the telescope at *A* above the ground or above a plug does not have to be known at all, unless the elevation of the ground or of the plug at that point is to be determined.

When it happens that the 5-ft. mark is not visible, the cross-hair may be set on some other foot mark, making note thereof, and proper attention must be paid to this fact when elevations are calculated.

As the 5-ft. increment of the rod is neither added nor subtracted in note-keeping it follows that all instrument station heights may be entered as ground heights, but that they are in fact fictitious. They are not the real instrument heights nor the exact ground heights at the instrument station, but are elevations 5 ft. lower than the actual height of the instrument. It is just the same as though the sights were along the dotted lines *A'B* and *A'C*, Fig. 18.

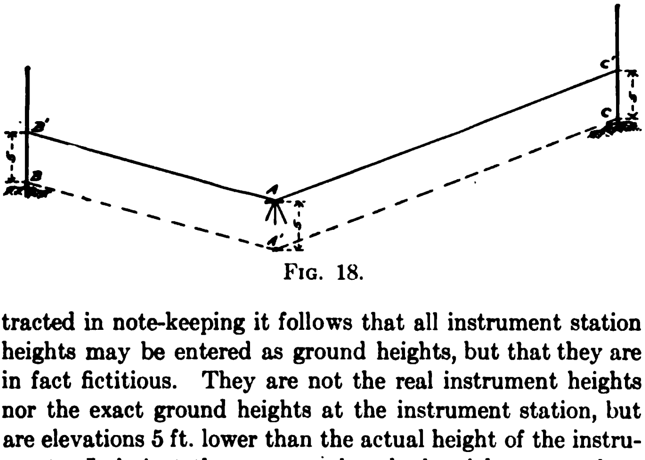

FIG. 18.

In using this method of surveying it is desirable to begin as in ordinary leveling by letting the rod be held at the starting point. It will be found a convenience, and the chance of error in platting will be reduced, if backsights are entered in the notes as though they were sights taken from the rod to the instrument.

The Liberal Use of the Magnetic Needle. Before presenting a sample page of notes it may be well to explain the method of topographic stadia surveying which led to the foregoing simplification. In difficult country it is often found impracticable to select instrument stations in advance and it is frequently embarrassing to be compelled to occupy stations selected by assistants. The operations of setting up and of orientation consume valuable time. To eliminate these disadvantages of the ordinary method of work—it being, of course, assumed that the necessary triangulation work, base-line surveying and precise leveling to establish reference points has been done—a start may be made at any point of known position and elevation.

The starting point may be called station zero. The rod is held at this point and the instrument is carried to the place from which sights can be taken to best advantage both with a view to getting the topography within reach and to making progress ahead.

The azimuth is now determined by magnetic needle. Unless, for some reason, the instrument point is to be preserved it need not be marked by a plug, neither is it necessary to determine the ground height at the instrument unless required by topographic considerations. The instrument station thus occupied is Station 1. The next turning point located by needle bearing, by stadia reading and by vertical angle is Station 2. The instrument is not set up at Station 2, but is carried on to Station 3, which is again selected with a view to comprehensive work. The position of Station 3 is fixed by direction and distance from 2, and so on. Backsights for azimuth must, of course, be taken with reversed telescope, or the south end of the magnetic needle must be read. Care must also be taken to give the vertical angle its proper sign. It will be noted that the line becomes a continuous traverse line, the odd-numbered stations being instrument stations, the others turning points.

For ground heights and short sights reliance may be had upon the small levels attached to the plate of the transit and perhaps in some cases to the horizontal position of the plane table. For each foresight and for each backsight the vertical circle should be set at zero; the telescope is then pointed toward the rod, the tripod head screws, in the case of a transit, are used to bring the telescope level and then the sight is taken. The accuracy with which such work can be done with a transit and the areas that can be covered are surprising. The author has often had two to three rodmen at work and has found no trouble in the office interpretation of the field notes.

The method of occupying with the instrument only the alternate or primary stations is particularly applicable in making surveys of reservoir and dam sites, in taking general topography over large areas and in securing data for topographic maps of mining ground.

The foregoing notes relating to the use of the magnetic needle in topographic surveying were written with special reference to surveys made with a transit. They are with slight modification of the text applicable also to plane-table map work.

It remains to be said that a magnetic needle 5 ins. long should enable the field work to be done with about the same degree of accuracy at which the data can be platted on a scale of about 200 ft. to the inch ($\frac{1}{2400}$). Longer needles or other methods of work should be used when maps on a very large scale are required and a very high degree of accuracy is demanded.

Stadia Notes. It has already been stated that the height at the instrument station, as carried into the notes, if the 5-ft. mark be selected as an arbitrary sighting-point, is a fictitious height 5 ft. lower than the actual height of the instrument. It often happens that many sights can be taken without noting the vertical angle by using the transit as a level. In all such cases the level foresight as made *should be recorded,* but this rod-reading should not be applied to the fictitous station height used in calculating elevations by vertical angle, but to the real height of the instrument. It will, therefore, be found convenient to insert in a "height of instrument" column the actual height of the instrument (the fictitious station height plus 5 ft.), subtracting from this, as in leveling, whenever the transit is used as a level.

The fictitious transit station elevation, it will be noted, is carried forward into the column for ground heights and is identified by underlining. To this transit station elevation all differences in elevation, as determined by vertical angles with sights to the 5-ft. mark, are applied to calculate the ground heights.

When, in taking a foresight or a sight to any point whose elevation is to be determined, the cross-hair in determining the vertical angle is set on some foot mark n other than the foot mark 5, then subtract $(n-5)$ from the elevation.

When a backsight is taken to any mark n on the rod other than the foot mark 5 then add to the new instrument station height $(n-5)$ ft.

The backsight which appears in the notes as though taken from an even numbered (secondary) station is, in fact, the first sight taken from the next instrument station. The notes thus become a simple combination of transit and level notes.

NOTE-BOOK—

LEFT-HAND PAGE

Rod Reading.	Distance.	Magnetic Course.	Vertical Angle.	Difference in Elevation.	Backsight.	Height of Instrument.	Level Sights, Foresight.
	Topog	raphic Su	rvey of				
		The Eagl	e Mine				
			Oct. 17,	1915			
		Station	0				
362	342	N27 15E	+13.21	+81.61			
		Station	1				
256	257	S31 35W	−2.52	−12.8	....	....	....
116	117	S80 30W	−3.17	−6.7	....	....	....
371	372	S83 25W	+2.00	+13.0	....	....	....
613	603	N45 00W	+8.14	+87.0	....	....	....
300	288	N36 10W	+12.05	+61.7	....	....	....
900	831	N3 15E	+16.09	+240.8	....	....	....
950	883	N20 30E	+15.30	−2.0+245.0	....	....	....
428	428	N85 00E	+2.17	+3.0+17.1	....	....	....
730	717	N60 10E	+8.07	+102.23	....	....	....
		Station	2				
436	437	N40 15E	....	....	6.17	327.43	....
		Station	3		327.43	....	....
925	926	S6 45E	....	....	....	....	8.3
706	707	N35 05E	....	....	....	....	3.16
		Station	4				
338	331	N62 30E	+9.11	+53.48	....	....	....

SAMPLE PAGES

RIGHT-HAND PAGE

Elevations.	Remarks.
	Transit No. 36.
	$e = 1.15$ ft.
	All vertical angle sights are to the 5-ft. mark on the rod unless otherwise noted.
	Odd-numbered points are the instrument stations.
	Even-numbered points are the turning points.
137.42	U. S. G. S. Bench, top of iron pipe, located, etc.
219 03	To Station 1 gentle slope to S.
219 03	
206.2	Bottom of gulch.
212.3	Slope to SW.
232.0	Bottom of gulch.
306.0	Bottom of gulch.
280.7	Slope to W.
459.8	Top of bluff.
462.0	To 7 ft. Top of bluff.
239.1	To 2 ft. Slope to S.
321.26	To station 2.
	To Station 3. The fictitious (though approximate) elevation of ground at Station 3, and Station elevation is found by subtracting 5 ft. from the H. I.
322.43	
319.1	At E. edge of timber.
324.27	To Station 4. Temporary B. M., etc.
324.27	
377.75	To Station 5.

NOTE-BOOK—

Rod Reading.	Distance.	Magnetic Course.	Vertical Angle.	Difference in Elevation.	Backsight.	Height of Instrument.	Level Sights, Foresight.
		Station	5			382.75	
516	511	N11 05W	−6.18	−56.4			
0	0						5.2
437	438	N36 10W					9.26
		Station	6				
462	461	N20 00E	−3.56	+3 −31.69			
		Station	7				
620	618	N10 00E	+4.12	+45.33			
417	417	N51 20E	−3.06	−22.57			
		Station	8A.				
516	511	N80 00E	+6.16	+56.13			
		Station	8B.				
565	538	N31 45E	+12.56	+123.51			
		Station	9				
		Etc.					

SAMPLE PAGES—*Continued*

Elevations.	Remarks.
377.75	
321.4	
377.6	Ground at instrument.
373.49	To Station 6.
373.49	
344.80	To 8 ft. to Station 7.
390.13	To Station 8A.
322.23	To Station 8B.
390.13	
446.26	To Station 9
322.23	
445.74	To Station 9
446.00	
Etc.	

Vertical Angles Measured with an Alidade. In using the alidade of the plane-table for measuring angles in a vertical plane, two readings on the vertical circle are necessary. First, the index error when the telescope, pointed toward the rod, is in a horizontal position; second, the angle when the telescope is depressed or elevated toward the sighting-point. A combination of the two readings gives the angle of depression or elevation. It would be a convenience to have the index arranged movable and provided with a tangent screw, similar to the lower plate of the transit, so that the telescope could be leveled carrying with it the index set at zero. Unclamping and sighting could then be followed, as with a transit, by a reading of the vertical angle freed from index error. The index error here referred to is due to the fact that a plane-table is not expected to have a perfectly true surface and cannot be leveled with the accuracy desirable in measuring vertical angles.

The Amount of Error when the Sighting Point does not Bisect the Intercept. The formulas presented in this manual are based on the assumption that the portion of the stadia rod which is read for distance is bisected by the middle cross-hair when the vertical angle is read. As a matter of fact this condition rarely obtains in practice. The lower cross-hair is set upon some foot mark and the intercept is read on the upper cross-hair, thereupon the middle cross-hair is set upon the sighting-point and the rodman is waved off.

In order that the topographer may have a clear conception of the error introduced when the rod is read for distance with the middle cross-hair at some point on the rod other than the sighting-point, Tables 1 and 2 have been prepared. It will be seen from these that for small vertical angles and sights of any length, very little attention need be paid to the portion of the rod used in measuring distance. The importance of having the middle cross-hair near the sighting-point when reading for distance, increases, regardless of the actual distance to the rod, as the angle of elevation or depression increases.

TABLE 1

TABLE OF CORRECTIONS TO BE APPLIED WHEN THE ROD IS READ WITH THE TELESCOPE AT A VERTICAL ANGLE OF *GREATER* AMPLITUDE THAN THE RECORDED VERTICAL ANGLE (TO THE SIGHTING-POINT). DECREASE THE DISTANCE AND DECREASE THE DIFFERENCE IN ELEVATION BY THE AMOUNTS NOTED IN THE TABLE

Rod Reading.	Middle Cross-hair Departures from the Sighting-point, Feet.	Vert. Angle = 1°		Vert. Angle = 5°		Vert. Angle = 10°		Vert. Angle = 20°		Vert. Angle = 30°	
		Corrections Feet.		Corrections Feet.		Corrections Feet.		Corrections Feet.		Corrections Feet.	
		Dist.	Elev.	Dist.	Elev.	Dist.	Elev.	Dist.	Elev.	Dist.	Elev.
100	1	.04	0	.18	.02	.34	.06	.66	.24	.86	.50
100	2	.13	0	.41	.04	.70	.13	1.32	.48	1.72	1.00
100	3	.23	0	.64	.06	1.07	.20	1.98	.73	2.58	1.50
100	4	.32	0	.87	.08	1.44	.27	2.65	.97	3.45	2.00
100	5	.42	0	1.11	.10	1.91	.34	3.32	1.21	4.32	2.50
200	1	.04	0	.2	.02	.3	.05	.6	.20	.9	.50
200	2	.10	0	.4	.03	.7	.12	1.3	.45	1.7	1.00
200	3	.17	0	.6	.05	1.1	.18	1.9	.70	2.6	1.50
200	4	.23	0	.8	.07	1.5	.25	2.6	.95	3.5	2.00
200	5	.30	0	1.0	.09	1.9	.32	3.3	1.20	4.3	2.50
500	1	.04	0	.2	.02	.3	.05	.6	.23	.9	.45
500	2	.08	0	.3	.03	.7	.11	1.2	.46	1.7	.95
500	3	.13	0	.5	.05	1.1	.17	1.9	.70	2.6	1.45
500	4	.18	0	.7	.06	1.5	.23	2.5	.93	3.4	1.95
500	5	.23	0	.9	.08	1.8	.30	3.2	1.16	4.3	2.45
1000	1	.03	0	.2	.02	.4	.06	.7	.23	.9	.45
1000	2	.07	0	.3	.03	.7	.12	1.3	.46	1.7	.95
1000	3	.11	0	.5	.05	1.0	.18	1.9	.70	2.6	1.40
1000	4	.15	0	.7	.06	1.3	.24	2.6	.93	3.4	1.90
1000	5	.20	0	.9	.08	1.7	.30	3.2	1.16	4.3	2.40

The tables are prepared as correction tables, but it will be well to remember that no correction is necessary if the rule be observed requiring the middle cross-hair to be first placed on the sighting-point, and then setting the lower cross-hair upon the foot mark nearest to the lowest cross-hair. The error under observance of this rule will be so small as to be negligible in all surveys, except in special cases where the highest attainable accuracy may be a requirement.

Whenever the bisecting point of the intercept is within one foot of the sighting-point the error in distance for any vertical angle less than 30° cannot exceed 1 ft.

TABLE 2

TABLE OF CORRECTIONS TO BE APPLIED WHEN THE ROD IS READ WITH THE TELESCOPE AS A VERTICAL ANGLE OF *LESS* AMPLITUDE THAN THE RECORDED VERTICAL ANGLE (TO THE SIGHTING-POINT). INCREASE THE DISTANCE AND INCREASE THE DIFFERENCE IN ELEVATION BY THE AMOUNTS NOTED IN THE TABLE

Rod Reading.	Middle Cross-hair Departures from the Sighting-point, Feet.	Vert. Angle = 1°		Vert. Angle = 5°		Vert. Angle = 10°		Vert. Angle = 20°		Vert. Angle = 30°	
		Corrections Feet.		Corrections Feet.		Corrections Feet.		Corrections Feet.		Corrections Feet.	
		Dist.	Elev.	Dist.	Elev.	Dist.	Elev.	Dist.	Elev.	Dist.	Elev.
100	1	.02	0	.16	.01	.33	.05	.63	.22	.87	.50
100	2	.03	0	.31	.03	.64	.10	1.25	.44	1.73	1.00
100	3	.02	0	.44	.04	.94	.16	1.85	.66	2.59	1.50
100	4	−.02	0	.54	.05	1.22	.21	2.44	.88	3.46	1.95
100	5	−.08	0	.62	.05	1.49	.26	3.07	1.10	4.32	2.40
200	1	.03	0	.2	.01	.3	.06	.6	.22	.9	.50
200	2	.05	0	.3	.03	.7	.12	1.2	.45	1.7	1.00
200	3	.06	0	.5	.04	1.0	.17	1.9	.67	2.6	1.50
200	4	.06	0	.6	.05	1.3	.23	2.6	.89	3.4	1.95
200	5	.05	0	.7	.06	1.6	.28	3.2	1.12	4.3	2.40
500	1	.03	0	.2	.01	.3	.06	.6	.23	.9	.50
500	2	.05	0	.3	.03	.7	.12	1.2	.46	1.7	1.00
500	3	.07	0	.5	.04	1.0	.17	1.9	.68	2.6	1.50
500	4	.09	0	.7	.06	1.3	.23	2.6	.91	3.4	1.95
500	5	.10	0	.8	.07	1.6	.28	3.2	1.14	4.3	2.40
1000	1	.03	0	.2	.01	.4	.06	.6	.23	.9	.50
1000	2	.06	0	.3	.03	.7	.12	1.3	.46	1.7	1.00
1000	3	.09	0	.5	.04	1.1	.18	1.9	.70	2.6	1.50
1000	4	.12	0	.7	.06	1.4	.24	2.6	.93	3.4	1.95
1000	5	.15	0	.8	.07	1.7	.30	3.2	1.16	4.3	2.40

The columns in the tables bearing the heading "Middle hair departures from the sighting-point" contain the departure of the bisecting point of the intercept from the sighting-point for which the corrections in the succeeding columns have been computed.

The sighting can, as stated, always be done in such manner that the use of these tables will not be necessary. Their introduction is mainly for the purpose of showing the errors that will result if proper attention be not paid to the part of the rod read for distance.

Amount of Error Due to Inclined Rod. If the stadia rod be not held in a true vertical position, or if, in the case of a sectional rod the face of the rod is in two or more planes, appreciable error may result. All such error should be avoided. Nevertheless in order that the magnitude thereof may not be underestimated attention is called to the following facts.

Let it be supposed that a rod is built up of two sections of which the uppermost is fastened to the back of the lower one and that the thickness of the lower section and, therefore, the departure of the upper section from the plane of the lower one is $\frac{7}{8}$ of an inch or .0875 ft.

If now a reading for distance is made on this rod with one cross-hair on the lower and one on the upper section the resulting error in distance will be:

For vertical angle + 5° rod reading too small by 0.8 ft.
For vertical angle +10° rod reading too small by 1.5 ft.
For vertical angle +20° rod reading too small by 3.2 ft.
For vertical angle +30° rod reading too small by 5.0 ft.
For vertical angle − 5° rod reading too large by 0.8 ft.
For vertical angle −10° rod reading too large by 1.5 ft.
For vertical angle −20° rod reading too large by 3.2 ft.
For vertical angle −30° rod reading too large by 5.0 ft.

It is to be noted that in the case of short sights the percentage of error when sighting up or down will be relatively high. The amount of this error is independent of the distance, being dependent solely upon the vertical angle of the sight and the departure of the surface on which one cross-hair is read from that on which the other is read.

When due to carelessness or any other cause the stadia rod is inclined forward or backward, and departs from a true vertical plane, the error will be as shown in Tables 3 and 4.

The Accuracy of Telemeter Surveys. The accuracy of the survey made with the telemeter and stadia rod is not readily determinable. The error in single readings may vary within considerable limits. The reading is affected not alone by the care with which the telemeter and the rod have been constructed, but also by atmospheric and light conditions and by the personal equation of the observer.

Under fair conditions the individual readings, when the distances do not exceed 800 ft. should have a probable error less than 1 in 500. When a survey is under consideration made up of a number of courses, aggregating about a mile in length, the error with ordinary care and with instruments suitable for ordinary good work, should not exceed 1 in 1000. When a still longer distance is measured by many sights, each less than 800 ft., the probable error will be less than this amount. According to the law of least squares, possibly 1 in 2000 when the aggregate length of the survey is about 4 miles.

In view of the relatively large possible error in a single sight, it would be useless to note distances other than to the nearest foot, when ordinary topographic surveys are involved. Elevations of temporary reference points, such as turning-points and of permanent bench marks, should be entered in the notes to hundredths. The height of instrument, too, should be entered to hundredths of a foot. The elevation of the ground at any point and the differences in elevation for use in determining ground heights should be *noted to* tenths only.

Table 3

CORRECTIONS FOR DEPARTURES OF THE STADIA ROD FROM A TRUE VERTICAL POSITION

(See also Table 4)

When sighting to a point higher than the instrument station and the rod is inclined backward, or when sighting to a point lower than the instrument station and the rod is inclined forward, correct the reading by the amounts noted in this table. The rod reading will be larger than it should be.

Vertical Angle.	Rod Reading.	Angle of Departure from the Vertical									
		1°		2°		3°		5°		10°	
	Ft.	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%
1°	100	− .04	.04	− .12	.12	− .23	.23	− .53	.53	− 1.82	1.82
	500	− .23	.04	− .60	.12	− 1.14	.23	− 2.65	.53	− 9.10	1.82
	1000	− .45	.04	− 1.21	.12	− 2.28	.23	− 5.32	.53	− 18.2	1.82
5°	100	− .17	.17	− .36	.36	− .59	.59	− 1.14	1.14	− 3.04	3.04
	500	− .84	.17	− 1.83	.36	− 2.97	.59	− 5.75	1.14	− 15.2	3.04
	1000	− 1.67	.17	− 3.65	.36	− 5.94	.59	−11.4	1.14	− 30.4	3.04
10°	100	− .32	.32	− .67	.67	− 1.06	1.06	− 1.93	1.92	− 4.59	4.59
	500	− 1.60	.32	− 3.37	.67	− 5.29	1.06	− 9.62	1.92	− 22.9	4.59
	1000	− 3.22	.32	− 6.75	.67	−10.57	1.06	−19.2	1.92	− 45.9	4.59
20°	100	− .65	.65	− 1.33	1.33	− 2.04	2.04	− 3.54	3.55	− 7.85	7.85
	500	− 3.24	.65	− 6.63	1.33	−10.17	2.04	−17.8	3.55	− 39.2	7.85
	1000	− 6.48	.65	−13.3	1.33	−20.4	2.04	−35.5	3.55	− 78.5	7.85
30°	100	− 1.02	1.02	− 2.07	2.07	− 3.15	3.15	− 5.40	5.41	− 11.6	11.6
	500	− 5.10	1.02	−10.3	2.07	−15.8	3.15	−27.1	5.41	− 57.8	11.6
	1000	−10.2	1.02	−20.7	2.07	−31.5	3.15	−54.1	5.41	−115.6	11.6

The corrections noted in this table are only those due to the inclination of that part of the rod covered by the intercept. They do not cover the error that is due to the fact that the point at which the lower cross-hair cuts the rod is in front of or beyond the base of the rod. The amount of this error depends not only on the inclination of the rod, but also on the height of the point where the lower cross-hair cuts the rod above the base of the rod.

Table 4

CORRECTIONS FOR DEPARTURES OF THE STADIA ROD FROM A TRUE VERTICAL POSITION

(See also Table 3)

When sighting to a point lower than the instrument station and the rod is inclined backward, or when sighting to a point higher than the instrument station and the rod is inclined forward, correct the reading by the amounts noted in this table. The rod reading may be either smaller or larger than it should be.

Vertical Angle.	Rod Reading.	Angle of Departure from the Vertical.									
		1°		2°		3°		5°		10°	
	Ft.	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%
1°	100	.02	.02	0	0	−.05	.05	− .23	.23	− 1.22	1.22
	500	.08	.02	0	0	−.23	.05	−1.15	.23	− 6.10	1.22
	1000	.15	.02	0	0	−.46	.05	−2.30	.23	−12.17	1.22
5°	100	.13	.13	.24	.24	.31	.31	.38	.38	0	0
	500	.68	.13	1.21	.24	1.60	.31	1.90	.38	0	0
	1000	1.37	.13	2.43	.24	3.20	.31	3.80	.38	0	0
10°	100	.30	.30	.55	.55	.55	.78	1.14	1.14	1.55	1.55
	500	1.45	.30	2.75	.55	3.91	.78	5.72	1.14	7.74	1.55
	1000	2.92	.30	5.53	.55	7.93	.78	11.4	1.14	15.5	1.55
20°	100	.61	.61	1.21	1.21	1.76	1.76	2.77	2.77	4.81	4.81
	500	3.08	.61	6.01	1.21	8.80	1.76	13.8	2.77	24.0	4.81
	1000	6.13	.61	12.1	1.21	16.7	1.76	27.7	2.77	48.1	4.81
30°	100	.99	.99	1.95	1.95	2.87	2.87	4.64	4.64	8.53	8.53
	500	4.94	.99	9.73	1.95	14.4	2.87	23.1	4.64	42.6	8.53
	1000	9.83	.99	19.5	1.95	28.7	2.87	46.3	4.64	85.2	8.53

The corrections noted in this table are only those due to the inclination of that part of the rod covered by the intercept. They do not cover the error that is due to the fact that the point at which the lower cross-hair cuts the rod is in front of or beyond the base of the rod. The amount of this error depends not only on the inclination of the rod but also on the height of the point where the lower cross-hair cuts the rod above the base of the rod.

The Effect of Refraction. As is well known the refraction of light rays is a function of the unequal density of the atmosphere. Near the ground surface, at times when there is material difference in the temperature of the air and of the ground, there may be a material variation in the refraction with but a few feet difference in the elevation of the light ray. The refraction will in other words be different for the light rays from the lower and upper portions of a telemeter rod. This fact and its influence upon the measurement of distances by means of a telescope and stadia rod has been ably discussed by Mr. L. S. Smith, C. E.,* and need not be dwelt upon here. It will suffice to say that the refraction effect upon the rod-readings is greatest at midday and is not the same on different days. The rating and testing of the telemeter should, therefore, be extended over a number of days and should include observations in the morning and evening as well as at midday.

Instances have been found where, in dry, arid regions such as Arizona, the errors due to refraction have been so great that the use of the ordinary stadia rod has had to be abandoned for accurate work. In such instances, the use of a horizontal rod with a special supporting device can be recommended.

* University of Wisconsin Bulletin, Engineering Series, Vol. 1, No. 5.

CHAPTER VII

THE PLATTING OF STADIA NOTES

When topographic surveys are made with a transit the field observations—except foresights and backsights—are usually reduced in the office, where, too, the notes are platted.

In order that the work may readily be manifolded the aim is to secure an inked copy on tracing linen or other transparent material with the least degree of labor.

The following procedure can be recommended:

Use an open protractor of thin material, such as paper, with radius equal to or greater than the lengths of the sights to be platted. Make the pencil drawing upon the rough side of tracing linen or upon tracing paper placed over cross-section or profile paper. The closely spaced parallel lines visible through the tracing linen are an invaluable aid in the quick orientation of the protractor whenever the azimuths are referred to the north line or whenever they are given in the relation to the cardinal points of the compass.

By placing a scale, or a marked ruler, or a strip of paper, north and south or east and west across the protractor, the same can be conveniently centered and oriented at one operation. No lines from instrument station to topographic points should be drawn. The only survey lines to appear on the drawing are those of the traverse from station to station. A fine needle at the instrument station from which the sights are being platted is a convenience and will decrease the liability of making errors in platting. Special scales with zero point swinging upon this needle and other devices to simplify the office work readily suggest themselves.

After the pencil drawing has been made and corrected to fit the controlling points of the survey, a fresh sheet of tracing linen is used upon which to ink the finished map. This is then available for any of the ordinary processes of manifolding, such as blue or black printing, photolithographing, etc.

CHAPTER VIII

TABLES

A NUMBER of tables are here presented which the surveyor who uses his transit as a telemeter or who makes topographic surveys with the plane table will find useful.

Table 5 gives the values of the terms $e \cos \alpha$ and $e \sin \alpha$ which appear in the correct stadia formulas (17) and (18) and covers all ordinary values of e. For each instrument, there being but one value of e, only a single line of the table will apply. This particular line should be made the basis of a secondary table for the topographer's own instrument, giving the values for each degree so that interpolation will be simplified.

TABLE 5

VALUES OF $e \cos \alpha$ AND $e \sin \alpha$ FOR DIFFERENT VALUES OF INSTRUMENT CONSTANT e AND DIFFERENT ANGLES OF ELEVATION α

All values in feet

Values of e	1°		5°		10°		15°		20°		30°	
	e cos	e sin	e cos	e sin	e cos	e sin	e cos	e sin	e cos	e sin	e cos	e sin
0.80	0.80	.01	.80	.07	.79	.14	.77	.21	.75	.27	.69	.40
1.00	1.00	.02	1.00	.09	.98	.17	.97	.26	.94	.34	.87	.50
1.20	1.20	.02	1.19	.10	1.18	.21	1.16	.31	1.13	.41	1.04	.60
1.40	1.40	.03	1.39	.12	1.38	.24	1.35	.36	1.32	.48	1.21	.70
1.60	1.60	.03	1.59	.14	1.57	.28	1.54	.41	1.50	.55	1.39	.80
1.80	1.80	.03	1.79	.16	1.77	.31	1.74	.47	1.69	.62	1.56	.90
2.00	2.00	.03	1.99	.17	1.97	.35	1.93	.52	1.88	.68	1.73	1.00
2.50	2.50	.04	2.49	.22	2.46	.43	2.41	.65	2.35	.85	2.16	1.25

STADIA REDUCTION TABLE

Table 6 is a stadia reduction table, checked by Mr. Otto von Geldern, to facilitate the solution of the equations.

$$D = r\cos^2\alpha + e\cos\alpha; \quad \dots \quad (17)$$

$$h = r\sin\alpha\cos\alpha + e\sin\alpha; \quad \dots \quad (18)$$

or

$$h = r\frac{\sin 2\alpha}{2} + e\sin\alpha. \quad \dots \quad (19)$$

The tables as here published contain only the increments

$$100\cos^2\alpha \quad \text{and} \quad 100\sin\alpha\cos\alpha.$$

In using formulas (17) and (18) the values taken from the tables are to be multiplied by $\frac{r}{100}$. In determining distance $e\cos\alpha$ and in determining difference in elevation $e\sin\alpha$ are then to be added to the values found in the tables. In illustrating the use of these tables Mr. von Geldern uses the following figures:

For a rod-reading $r = 285$ ft. and a vertical angle 10° 12′ there will be found in the table in the column " Hor. Dist." 96.86 and in the column " Diff. Elev." 17.43; in other words

$$100\cos^2(10° 12') = 96.86 \text{ ft.},$$

and

$$100\sin(10° 12')\cos(10° 12') = 17.43 \text{ ft.}$$

Both of these values are to be multiplied by $\frac{285}{100} = 2.85$. Therefore

$$285\cos^2(10° 12') = 2.85 \times 96.86 = 276.05;$$

$$285\sin(10° 12')\cos(10° 12') = 2.85 \times 17.43 = 49.67.$$

If a large ordinary transit has been used the value of e will be about 1.15 ft., and therefore

$$1.15 \cos (10° \; 12') = 1.13;$$

and

$$1.15 \sin (10° \; 12') = 0.21,$$

consequently

$$D = 276.05 + 1.13 = 277.18;$$

$$h = 49.67 + 0.21 = 49.88.$$

The chief value of Table 6 lies in the fact that it is applicable to the solution of the approximation formulas which are recommended in this manual for use in stadia surveying. Thus in the case of

$$(27) \quad D = (r + e) \cos^2 \alpha;$$

and

$$(28) \quad h = (r + e) \sin \alpha \cos \alpha.$$

For the special case $(r+e) = 285 + 1.15 = 286.15$;

$$D = \frac{286.15}{100} \times 96.86 = 277.16 \text{ ft.};$$

$$h = \frac{286.15}{100} \times 17.43 = 49.88 \text{ ft.}$$

Again in the case of

$$(29) \quad D = (r + 1) \cos^2 \alpha;$$

$$(30) \quad h = (r + 1) \sin \alpha \cos \alpha.$$

For the special case of $(r+1) = 286$;

$$D = \frac{286}{100} \times 96.86 = 277.02 \text{ ft.};$$

$$h = \frac{286}{100} \times 17.43 = 49.85 \text{ ft.}$$

Table 6

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column "Hor. Dist." find: $100 \cos^2 \alpha$
In the column "Diff. Elev." find: $100 \sin \alpha \cos \alpha$

Rod Vertical

Min.	0°		1°		2°		3°		4°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	100.00	.00	99.97	1.74	99.88	3.49	99.73	5.23	99.51	6.96
2	100.00	.06	99.97	1.80	99.87	3.55	99.72	5.28	99.51	7.02
4	100.00	.12	99.97	1.86	99.87	3.60	99.71	5.34	99.50	7.07
6	100.00	.17	99.96	1.92	99.87	3.66	99.71	5.40	99.49	7.13
8	100.00	.23	99.96	1.98	99.86	3.72	99.70	5.46	99.48	7.19
10	100.00	.29	99.96	2.04	99.86	3.78	99.69	5.52	99.47	7.25
12	100.00	.35	99.96	2.09	99.85	3.84	99.69	5.57	99.46	7.30
14	100.00	.41	99.95	2.15	99.85	3.90	99.68	5.63	99.46	7.36
16	100.00	.47	99.95	2.21	99.84	3.95	99.68	5.69	99.45	7.42
18	100.00	.52	99.95	2.27	99.84	4.01	99.67	5.75	99.44	7.48
20	100.00	.58	99.95	2.33	99.83	4.07	99.66	5.80	99.43	7.53
22	100.00	.64	99.94	2.38	99.83	4.13	99.66	5.86	99.42	7.59
24	100.00	.70	99.94	2.44	99.82	4.18	99.65	5.92	99.41	7.65
26	99.99	.76	99.94	2.50	99.82	4.24	99.64	5.98	99.40	7.71
28	99.99	.81	99.93	2.56	99.81	4.30	99.63	6.04	99.39	7.76
30	99.99	.87	99.93	2.62	99.81	4.36	99.63	6.09	99.38	7.82
32	99.99	.93	99.93	2.67	99.80	4.42	99.62	6.15	99.38	7.88
34	99.99	.99	99.93	2.73	99.80	4.48	99.62	6.21	99.37	7.94
36	99.99	1.05	99.92	2.79	99.79	4.53	99.61	6.27	99.36	7.99
38	99.99	1.11	99.92	2.85	99.79	4.59	99.60	6.33	99.35	8.05
40	99.99	1.16	99.92	2.91	99.78	4.65	99.59	6.38	99.34	8.11
42	99.98	1.22	99.91	2.97	99.78	4.71	99.59	6.44	99.33	8.17
44	99.98	1.28	99.91	3.02	99.77	4.76	99.58	6.50	99.32	8.22
46	99.98	1.34	99.90	3.08	99.77	4.82	99.57	6.56	99.31	8.28
48	99.98	1.40	99.90	3.14	99.76	4.88	99.56	6.61	99.30	8.34
50	99.98	1.45	99.90	3.20	99.76	4.94	99.56	6.67	99.29	8.40
52	99.98	1.51	99.89	3.26	99.75	4.99	99.55	6.73	99.28	8.45
54	99.98	1.57	99.89	3.31	99.74	5.05	99.54	6.78	99.27	8.51
56	99.97	1.63	99.89	3.37	99.74	5.11	99.53	6.84	99.26	8.57
58	99.97	1.69	99.88	3.43	99.73	5.17	99.52	6.90	99.25	8.63
60	99.97	1.74	99.88	3.49	99.73	5.23	99.51	6.96	99.24	8.68

TABLE 6.—*Continued*

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column " Hor. Dist." find: 100 $\cos^2 \alpha$
In the column " Diff. Elev." find: 100 $\sin \alpha \cos \alpha$

Rod Vertical

Min.	5°		6°		7°		8°		9°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	99.24	8.68	98.91	10.40	98.51	12.10	98.06	13.78	97.55	15.45
2	99.23	8.74	98.90	10.45	98.50	12.15	98.05	13.84	97.53	15.51
4	99.22	8.80	98.88	10.51	98.48	12.21	98.03	13.89	97.52	15.56
6	99.21	8.85	98.87	10.57	98.47	12.26	98.01	13.95	97.50	15.62
8	99.20	8.91	98.86	10.62	98.46	12.32	98.00	14.01	97.48	15.67
10	99.19	8.97	98.85	10.68	98.44	12.38	97.98	14.06	97.46	15.73
12	99.18	9.03	98.83	10.74	98.43	12.43	97.97	14.12	97.44	15.78
14	99.17	9.08	98.82	10.79	98.41	12.49	97.95	14.17	97.43	15.84
16	99.16	9.14	98.81	10.85	98.40	12.55	97.93	14.23	97.41	15.89
18	99.15	9.20	98.80	10.91	98.39	12.60	97.92	14.28	97.39	15.95
20	99.14	9.25	98.78	10.96	98.37	12.66	97.90	14.34	97.37	16.00
20	99.13	9.31	98.77	11.02	98.36	12.72	97.88	14.40	97.35	16.06
22	99.11	9.37	98.76	11.08	98.34	12.77	97.87	14.45	97.33	16.11
24	99.10	9.43	98.74	11.13	98.33	12.83	97.85	14.51	97.31	16.17
26	99.09	9.48	98.73	11.19	98.31	12.88	97.83	14.56	97.29	16.22
28	99.08	9.54	98.72	11.25	98.29	12.94	97.82	14.62	97.28	16.28
30	99.07	9.60	98.71	11.30	98.28	13.00	97.80	14.67	97.26	16.33
32	99.06	9.65	98.69	11.36	98.27	13.05	97.78	14.73	97.24	16.39
36	99.05	9.71	98.68	11.42	98.25	13.11	97.76	14.79	97.22	16.44
38	99.64	9.77	98.67	11.47	98.24	13.17	97.75	14.84	97.20	16.50
40	99.03	9.83	98.65	11.53	98.22	13.22	97.73	14.90	97.18	16.55
42	99.01	9.88	98.64	11.59	98.20	13.28	97.71	14.95	97.16	16.61
44	99.00	9.94	98.63	11.64	98.19	13.33	97.69	15.01	97.14	16.66
46	98.99	10.00	98.61	11.70	98.17	13.39	97.68	15.06	97.12	16.72
48	98.98	10.05	98.60	11.76	98.16	13.45	97.66	15.12	97.10	16.77
50	98.97	10.11	98.58	11.81	98.14	13.50	97.64	15.17	97.08	16.83
52	98.96	10.17	98.57	11.87	98.13	13.56	97.62	15.23	97.06	16.88
54	98.94	10.22	98.56	11.93	98.11	13.61	97.61	15.28	97.04	16.94
56	98.93	10.28	98.54	11.98	98.10	13.67	97.59	15.34	97.02	16.99
58	98.92	10.34	98.53	12.04	98.08	13.73	97.57	15.40	97.00	17.05
60	98.91	10.40	98.51	12.10	98.06	13 78	97.55	15.45	96.98	17.10

TABLE 6.—*Continued*

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column " Hor. Dist." find: 100 $\cos^2 \alpha$

In the column " Diff. Elev." find: 100 $\sin \alpha \cos \alpha$

Rod Vertical

Min.	10°		11°		12°		13°		14°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	96.98	17.10	96.36	18.73	95.68	20.34	94.94	21.92	94.15	23.47
2	96.96	17.16	96.34	18.78	95.65	20.39	94.91	21.97	94.12	23.52
4	96.94	17.21	96.32	18.84	95.63	20.44	94.89	22.02	94.09	23.58
6	96.92	17.26	96.29	18.89	95.61	20.50	94.86	22.08	94.07	23.63
8	96.90	17.32	96.27	19.85	95.58	20.55	94.84	22.13	94.04	23.68
10	96.88	17.37	96.25	19.00	95.56	20.60	94.81	22.18	94.01	23.73
12	96.86	17.43	96.23	19.05	95.53	20.66	94.79	22.23	93.98	23.78
14	96.84	17.48	96.21	19.11	95.51	20.71	94.77	22.28	93.95	23.83
16	96.82	17.54	96.18	19.16	95.49	20.76	94.73	22.34	93.93	23.88
18	96.80	17.59	96.16	19.21	95.46	20.81	94.71	22.39	93.90	23.93
20	96.78	17.65	96.14	19.27	95.44	20.87	94.68	22.44	93.87	23.99
22	96.76	17.70	96.12	19.32	95.41	20.92	94.66	22.49	93.84	24.04
24	96.74	17.76	96.09	19.38	95.39	20.97	94.63	22.54	93.81	24.09
26	96.72	17.81	96.07	19.43	95.36	21.03	94.60	22.60	93.79	24.14
28	96.70	17.86	96.05	19.48	95.34	21.08	94.58	22.65	93.76	24.19
30	96.68	17.92	96.03	19.54	95.32	21.13	94.55	22.70	93.73	24.24
32	96.66	17.97	96.00	19.59	95.29	21.18	94.52	22.75	93.70	24.29
34	96.64	18.03	95.98	19.64	95.27	21.24	94.50	22.80	93.67	24.34
36	96.62	18.08	95.96	19.70	95.24	21.29	94.47	22.85	93.65	24.39
38	96.60	18.14	95.93	19.75	95.22	21.34	94.44	22.91	93.62	24.44
40	96.57	18.19	95.91	19.80	95.19	21.39	94.42	22.96	93.59	24.49
42	96.55	18.24	95.89	19.86	95.17	21.45	94.39	23.01	93.56	24.55
44	96.53	18.30	95.86	19.91	95.14	21.50	94.36	23.06	93.53	24.60
46	96.51	18.35	95.84	19.96	95.12	21.55	94.34	23.11	93.50	24.65
48	96.49	18.41	95.82	20.02	95.09	21.60	94.31	23.16	93.47	24.70
50	96.47	18.46	95.79	20.07	95.07	21.66	94.28	23.22	93.45	24.75
52	96.45	18.51	95.77	20.12	95.04	21.71	94.26	23.27	93.42	24.80
54	96.42	18.57	95.75	20.18	95.02	21.76	94.23	23.32	93.39	24.85
56	96.40	18.62	95.72	20.23	94.99	21.81	94.20	23.37	93.36	24.90
58	96.38	18.68	95.70	20.28	94.97	21.87	94.17	23.42	93.33	24.95
60	96.36	18.73	95.68	20.34	94.94	21.92	94.15	23.47	93.30	25.00

TABLE 6—*Continued*

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column " Hor. Dist." find 100 $\cos^2 \alpha$

In the column " Diff. Elev." find: 100 $\sin \alpha \cos \alpha$

Rod Vertical

Min.	15°		16°		17°		18°		19°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	93.30	25.00	92.40	26.50	91.45	27.96	90.45	29.39	89.40	30.78
2	93.27	25.05	92.37	26.55	91.42	28.01	90.42	29.44	89.36	30.83
4	93.24	25.10	92.34	26.59	91.39	28.06	90.38	29.48	89.33	30.87
6	93.21	25.15	92.31	26.64	91.35	28.10	90.35	29.53	89.29	30.92
8	93.18	25.20	92.28	26.68	91.32	28.15	90.31	29.58	89.26	30.97
10	93.10	25.25	92.25	26.74	91.29	28.20	90.28	29.62	89.22	31.01
12	93.13	25.30	92.22	26.79	91.26	28.25	90.24	29.67	89.18	31.06
14	93.10	25.35	92.19	26.84	91.22	28.30	90.21	29.72	89.15	31.10
16	93.07	25.40	92.15	26.89	91.19	28.34	90.18	29.76	89.11	31.15
18	93.04	25.45	92.12	26.94	91.16	28.39	90.14	29.81	89.08	31.19
20	93.01	25.50	92.09	26.99	91.12	28.44	90.11	29.86	89.04	31.24
22	92.98	25.55	92.06	27.04	91.09	28.49	90.07	29.90	89.00	31.28
24	92.95	25.60	92.03	27.09	91.06	28.54	90.04	29.95	88.96	31.33
26	92.92	25.65	92.00	27.13	91.02	28.58	90.00	30.00	88.93	31.38
28	92.89	25.70	91.97	27.18	90.99	28.63	89.97	30.04	88.89	31.42
30	92.86	25.75	91.93	27.23	90.96	28.68	89.93	30.09	88.86	31.47
32	92.83	25.80	91.90	27.28	90.92	28.73	89.90	30.14	88.82	31.51
34	92.80	25.85	91.87	27.33	90.89	28.77	89.86	30.19	88.78	31.56
36	92.77	25.90	91.84	27.38	90.86	28.82	89.83	30.23	88.75	31.60
38	92.74	25.95	91.81	27.43	90.82	28.87	89.79	30.28	88.71	31.65
40	92.71	26.00	91.77	27.48	90.79	28.92	89.76	30.32	88.67	31.69
42	92.68	26.05	91.74	27.52	90.76	28.96	89.72	30.37	88.64	31.74
44	92.65	26.10	91.71	27.57	90.72	29.01	89.69	30.41	88.60	31.78
46	92.62	26.15	91.68	27.62	90.69	29.06	89.65	30.46	88.56	31.83
48	92.59	26.20	91.65	27.67	90.66	29.11	89.61	30.51	88.53	31.87
50	92.56	26.25	91.61	27.72	90.62	29.15	89.58	30.55	88.49	31.92
52	92.53	26.30	91.58	27.77	90.59	29.20	89.54	30.60	88.45	31.96
54	92.49	26.35	91.55	27.81	90.55	29.25	89.51	30.65	88.41	32.01
56	92.46	26.40	91.52	27.86	90.52	29.30	89.47	30.69	88.38	32.05
58	92.43	26.45	91.48	27.91	90.48	29.34	89.44	30.74	88.34	32.09
60	92.40	26.50	91.45	27.96	90.45	29.39	89.40	30.78	88.30	32.14

TABLE 6—*Continued*

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column " Hor. Dist." find: 100 cos² α

In the column " Diff. Elev." find: 100 sin α cos α

Rod Vertical

Min.	20°		21°		22°		23°		24°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	88.30	32.14	87.16	33.46	85.97	34.73	84.73	35.97	83.46	37.16
2	88.26	32.18	87.12	33.50	85.93	34.77	84.69	36.01	83.41	37.20
4	88.23	32.23	87.08	33.54	85.89	34.82	84.65	36.05	83.37	37.23
6	88.19	32.27	87.04	33.59	85.85	34.86	84.61	36.09	83.33	37.27
8	88.15	32.32	87.00	33.63	85.80	34.90	84.57	36.13	83.28	37.31
10	88.11	32.36	86.96	33.67	85.76	34.94	84.52	36.17	83.24	37.35
12	88.08	32.41	86.92	33.72	85.72	34.98	84.48	36.21	83.20	37.39
14	88.04	32.45	86.88	33.76	85.68	35.02	84.44	36.25	83.15	37.43
16	88.00	32.49	86.84	33.80	85.64	35.07	84.40	36.29	83.11	37.47
18	87.96	32.54	86.80	33.84	85.60	35.11	84.35	36.33	83.07	37.51
20	87.93	32.58	86.77	33.89	85.56	35.15	84.31	36.37	83.02	37.54
22	87.89	32.63	86.73	33.93	85.52	35.19	84.27	36.41	82.98	37.58
24	87.85	32.67	86.69	33.97	85.48	35.23	84.23	36.45	82.93	37.62
26	87.81	32.72	86.65	34.01	85.44	35.27	84.18	36.49	82.89	37.66
28	87.77	32.76	86.61	34.06	85.40	35.31	84.14	36.53	82.85	37.70
30	87.74	32.80	86.57	34.10	85.36	35.36	84.10	36.57	82.80	37.74
32	87.70	32.85	86.53	34.14	85.31	35.40	84.06	36.61	82.76	37.77
34	87.66	32.89	86.49	34.18	85.27	35.44	84.01	36.65	82.72	37.81
36	87.62	32.93	86.45	34.23	85.23	35.48	83.97	36.69	82.67	37.85
38	87.58	32.98	86.41	34.27	85.19	35.52	83.93	36.73	82.63	37.89
40	87.54	33.02	86.37	34.31	85.15	35.56	83.89	36.77	82.58	37.93
42	87.51	33.07	86.33	34.35	85.11	35.60	83.84	36.80	82.54	37.96
44	87.47	33.11	86.29	34.40	85.07	35.64	83.80	36.84	82.49	38.00
46	87.43	33.15	86.25	34.44	85.02	35.68	83.76	36.88	82.45	38.04
48	87.39	33.20	86.21	34.48	84.98	35.72	83.72	36.92	82.41	38.08
50	87.35	33.24	86.17	34.52	84.94	35.76	83.67	36.96	82.36	38.11
52	87.31	33.28	86.13	34.57	84.90	35.80	83.63	37.00	82.32	38.15
54	87.27	33.33	86.09	34.61	84.86	35.85	83.59	37.04	82.27	38.19
56	87.24	33.37	86.05	34.65	84.82	35.89	83.54	37.08	82.23	38.23
58	87.20	33.41	86.01	34.69	84.77	35.93	83.50	37.12	82.18	38.26
60	87.16	33.46	85.97	34.73	84.73	35.97	83.46	37.16	82.14	38.30

TABLE 6—*Continued*

STADIA REDUCTION TABLE

For instruments rated 1 to 100

In the column " Hor. Dist." find: $100 \cos^2 \alpha$

In the column " Diff. Elev." find: $100 \sin \alpha \cos \alpha$

Rod Vertical

Min.	25°		26°		27°		28°		29°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	82.14	38.30	80.78	39.40	79.39	40.45	77.96	41.45	76.50	42.40
2	82.09	38.34	80.74	39.44	79.34	40.49	77.91	41.48	76.45	42.43
4	82.05	38.38	80.69	39.47	79.30	40.52	77.86	41.52	76.40	42.46
6	82.01	38.41	80.65	39.51	79.25	40.55	77.81	41.55	76.35	42.49
8	81.96	38.45	80.60	39.54	79.20	40.59	77.77	41.58	76.30	42.53
10	81.92	38.49	80.55	39.58	79.15	40.62	77.72	41.61	76.25	42.56
12	81.87	38.53	80.51	39.61	79.11	40.66	77.67	41.65	76.20	42.59
14	81.83	38.56	80.46	39.65	79.06	40.69	77.62	41.68	76.15	42.62
16	81.78	38.60	80.41	39.69	79.01	40.72	77.57	41.71	76.10	42.65
18	81.74	38.64	80.37	39.72	78.96	40.76	77.52	41.74	76.05	42.68
20	81.69	38.67	80.32	39.76	78.92	40.79	77.48	41.77	76.00	42.71
22	81.65	38.71	80.28	39.79	78.87	40.82	77.42	41.81	75.95	42.74
24	81.60	38.75	80.23	39.83	78.82	40.86	77.38	41.84	75.90	42.77
26	81.56	38.78	80.18	39.86	78.77	40.89	77.33	41.87	75.85	42.80
28	81.51	38.82	80.14	39.90	78.73	40.92	77.28	41.90	75.80	42.83
30	81.47	38.86	80.09	39.93	78.68	40.96	77.23	41.93	75.75	42.86
32	81.42	38.89	80.04	39.97	78.63	40.99	77.18	41.97	75.70	42.89
34	81.38	38.93	80.00	40.00	78.58	41.02	77.13	42.00	75.65	42.92
36	81.33	38.97	79.95	40.04	78.54	41.06	77.09	42.03	75.60	42.95
38	81.28	39.00	79.90	49.07	78.49	41.09	77.04	42.06	75.55	42.98
40	81.24	39.04	79.86	40.11	78.44	41.12	76.99	42.09	75.50	43.01
42	81.19	39.08	79.81	40.14	78.39	41.16	76.94	42.12	75.45	43.04
44	81.15	39.11	79.76	40.18	78.34	41.19	76.89	42.15	75.40	43.07
46	81.10	39.15	79.72	40.21	78.30	41.22	76.84	42.19	75.35	43.10
48	81.06	39.18	79.67	40.24	78.25	41.26	76.79	42.22	75.30	43.13
50	81.01	39.22	79.62	40.28	78.20	41.29	76.74	42.25	75.25	43.16
52	80.97	39.26	79.58	40.31	78.15	41.32	76.69	42.28	75.20	43.18
54	80.92	39.29	79.53	40.35	78.10	41.35	76.64	42.31	75.15	43.21
56	80.87	39.33	79.48	40.40	78.06	41.39	76.59	42.34	75.10	43.24
58	80.83	39.36	79.44	40.42	78.01	41.42	76.55	42.37	75.05	43.27
60	80.78	39.40	79.39	40.45	77.96	41.45	76.50	42.40	75.00	43.30

ANDERSON'S STADIA REDUCTION TABLE

(As prepared and in use by U. S. Geological Survey)

Explanation of Table: Table 7 is particularly useful when topographic surveys of large areas are to be made. It was prepared by Mr. C. G. Anderson and has been published by the U. S. Geological Survey in a pamphlet entitled "Tables for Obtaining Differences of Elevation," 1909. It is reprinted here with the permission of the Survey. In the U. S. G. S. pamphlet the table from 0° to 5° angle of elevation includes rod-readings to 3500 ft. though here reproduced to only 2600 ft.

The figures in the body of the table give "Differences in Elevation" in feet for rod-readings in feet, read on a rod held vertically.

The degrees of vertical angle are printed at the top of each page; the minutes in the right or left-hand vertical columns.

The figures in the *top horizontal line* are the rod-readings (=intercept times rating factor).

The figures in the bottom *horizontal* line are the correct horizontal distances based on the middle (30′) angle of the page.

The horizontal distances were computed by the formula

$$D = r \cos^2 \alpha. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

To increase the usefulness of these tables, there has been added, at the bottom of each page, a correction for distance which has been given for each departure of 10′ from the angle for which distance is noted in the table. The basic angle for distance, as already stated, is in each case the half degree. For all vertical angles on any page or in any column less than this basic angle, *i.e.*, above the 30′ line, the correction will be positive, it will be added to the distance at the bottom of the page or column; and for all vertical angles larger than the basic angle, *i.e.*, below the 30′ line, the correction is to be subtracted.

The differences in elevation were computed by the formula:

$$h = r \sin \alpha \cos \alpha. \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

As elsewhere explained in this manual a somewhat closer approximation, when surveys are made with ordinary instruments, can be obtained by entering the table with $(r+e)$ or $(r+1)$ instead of with r. This applies both in the matter of difference in elevation and distance.

This table as is seen from the above formulas was prepared for use as an approximation table and in this respect ranks with Table 6. When more than ordinary accuracy is required the corrections $e \cos \alpha$ and $e \sin \alpha$ can be added to the values taken from the table when entered with the rod-reading r.

Tabular values for the omitted columns, viz.: 1000, 2000, and 3000, can be obtained from columns 100, 200 and 300, respectively, by moving the decimal point one place to the right.

Tabular values beyond the range of the table can be obtained by moving the decimal point to right or left, as shown in the following example:

Required the difference in elevation for an angle of 3° 16′ for a rod-reading of 3644 ft. (*i.e.*, intercept of half stadia interval, 18.22 times 200 = 3644 ft.). In this case $(r+1)$ = 3645 ft.

For 3000 ft. (from 300 ft. moving the decimal to right)	170.7 ft.
For 600 ft.	34.1 ft.
For 40 ft. (from 400 ft. moving the decimal point to left)	2.28 ft.
For 5 ft. (from 500 ft. moving the decimal point two places to left)	.28 ft.
Difference in elevation	207.4 ft.

The distance in the case of this example is found by the aid of the table to be 3634 ft., as follows:

For 3° 30′	
For 3000 ft. (from 300 ft. moving the decimal point to right)	2989 ft.
For 600 ft.	598 ft.
For 40 ft. (from 400 ft. moving the decimal point to left)	40 ft.
For 5 ft. (from 500 ft. moving the decimal point two places to left)	5 ft.
Distance from table	3632 ft.
For 3° 16′ being 14′ less than 3° 30′ add: $1.4 \times 36.3 \times .035 = 1.78$ or	2 ft.
Corrected distance is	3634 ft.

TABLE 7
DIFFERENCES IN ELEVATION
0°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
1	0.03	0.06	0.09	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4
2	0.06	0.12	0.17	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8
3	0.09	0.18	0.26	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.0	1.1
4	0.12	0.23	0.35	0.4	0.6	0.7	0.8	0.9	1.0	1.3	1.4	1.5
5	0.15	0.29	0.44	0.6	0.7	0.9	1.0	1.2	1.3	1.6	1.7	1.9
6	0.18	0.35	0.52	0.7	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3
7	0.20	0.41	0.61	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6
8	0.23	0.46	0.70	0.9	1.2	1.4	1.6	1.9	2.1	2.6	2.8	3.0
9	0.26	0.52	0.79	1.0	1.3	1.6	1.8	2.1	2.4	2.9	3.1	3.4
10	0.29	0.58	0.87	1.2	1.5	1.7	2.0	2.3	2.6	3.2	3.5	3.8
11	0.32	0.64	0.96	1.3	1.6	1.9	2.2	2.6	2.9	3.5	3.8	4.2
12	0.35	0.70	1.05	1.4	1.7	2.1	2.4	2.8	3.1	3.8	4.2	4.5
13	0.38	0.77	1.13	1.5	1.9	2.3	2.6	3.0	3.4	4.2	4.5	4.9
14	0.41	0.81	1.22	1.6	2.0	2.4	2.8	3.3	3.7	4.5	4.9	5.3
15	0.44	0.87	1.31	1.7	2.2	2.6	3.1	3.5	3.9	4.8	5.2	5.7
16	0.47	0.93	1.40	1.9	2.3	2.8	3.3	3.7	4.2	5.1	5.6	6.0
17	0.49	0.99	1.48	2.0	2.5	3.0	3.5	4.0	4.4	5.4	5.9	6.4
18	0.52	1.05	1.57	2.1	2.6	3.1	3.7	4.2	4.7	5.8	6.3	6.8
19	0.55	1.10	1.66	2.2	2.8	3.3	3.9	4.4	4.5	6.1	6.6	7.2
20	0.58	1.16	1.75	2.3	2.9	3.5	4.1	4.7	5.2	6.4	7.0	7.6
21	0.61	1.22	1.83	2.4	3.1	3.7	4.3	4.9	5.5	6.7	7.3	7.9
22	0.64	1.28	1.92	2.6	3.2	3.8	4.5	5.1	5.8	7.0	7.7	8.3
23	0.67	1.34	2.01	2.7	3.3	4.0	4.7	5.4	6.0	7.4	8.0	8.7
24	0.70	1.40	2.09	2.8	3.5	4.2	4.9	5.6	6.3	7.7	8.4	9.1
25	0.73	1.45	2.18	2.9	3.6	4.4	5.1	5.8	6.5	8.0	8.7	9.4
26	0.76	1.51	2.27	3.0	3.8	4.5	5.3	6.0	6.8	8.3	9.1	9.8
27	0.79	1.57	2.36	3.1	3.9	4.7	5.5	6.3	7.1	8.6	9.4	10.2
28	0.81	1.63	2.44	3.3	4.1	4.9	5.7	6.5	7.3	9.0	9.8	10.6
29	0.84	1.69	2.53	3.4	4.2	5.1	5.9	6.7	7.6	9.3	10.1	11.1
30	0.87	1.74	2.62	3.5	4.4	5.2	6.1	7.0	7.8	9.6	10.5	11.3
31	0.90	1.80	2.70	3.6	4.5	5.4	6.3	7.2	8.1	9.9	10.8	11.7
32	0.93	1.86	2.79	3.7	4.7	5.6	6.5	7.4	8.4	10.2	11.2	12.1
33	0.96	1.92	2.88	3.8	4.8	5.8	6.7	7.7	8.6	10.6	11.5	12.5
34	0.99	1.98	2.97	4.0	4.9	5.9	6.9	7.9	8.9	10.9	11.9	12.9
35	1.02	2.04	3.05	4.1	5.1	6.1	7.1	8.1	9.2	11.2	12.2	13.2
36	1.05	2.09	3.14	4.2	5.2	6.3	7.3	8.4	9.4	11.5	12.6	13.6
37	1.08	2.15	3.23	4.3	5.4	6.5	7.5	8.6	9.7	11.8	12.9	14.0
38	1.11	2.21	3.32	4.4	5.5	6.6	7.7	8.8	9.9	12.2	13.3	14.4
39	1.13	2.27	3.40	4.5	5.7	6.8	8.0	9.1	10.2	12.5	13.6	14.7
40	1.16	2.33	3.49	4.7	5.8	7.0	8.1	9.3	10.5	12.8	14.0	15.1
41	1.19	2.38	3.58	4.8	6.0	7.2	8.3	9.5	10.7	13.1	14.3	15.5
42	1.22	2.44	3.66	4.9	6.1	7.3	8.6	9.8	11.0	13.4	14.7	15.9
43	1.25	2.50	3.75	5.0	6.2	7.5	8.8	10.0	11.2	13.8	15.0	16.2
44	1.28	2.56	3.84	5.1	6.4	7.7	9.0	10.2	11.5	14.1	15.4	16.6
45	1.31	2.62	3.93	5.2	6.5	7.8	9.2	10.5	11.8	14.4	15.7	17.0
46	1.34	2.63	4.01	5.4	6.7	8.0	9.4	10.7	12.0	14.7	16.1	17.4
47	1.37	2.73	4.10	5.5	6.8	8.2	9.6	10.9	12.3	15.0	16.4	17.8
48	1.40	2.79	4.19	5.6	7.0	8.4	9.8	11.2	12.6	15.4	16.8	18.1
49	1.42	2.85	4.28	5.7	7.1	8.6	10.0	11.4	12.8	15.7	17.1	18.5
50	1.45	2.91	4.36	5.8	7.3	8.7	10.2	11.6	13.1	16.0	17.4	18.9
51	1.48	2.97	4.45	5.9	7.4	8.9	10.4	11.9	13.4	16.3	17.8	19.3
52	1.51	3.02	4.54	6.0	7.6	9.1	10.6	12.1	13.6	16.6	18.2	19.7
53	1.54	3.08	4.62	6.2	7.7	9.2	10.8	12.3	13.9	17.0	18.5	20.0
54	1.57	3.14	4.71	6.3	7.8	9.4	11.0	12.6	14.1	17.3	18.8	20.4
55	1.60	3.20	4.80	6.4	8.0	9.6	11.2	12.8	14.4	17.6	19.2	20.8
56	1.63	3.26	4.88	6.5	8.1	9.8	11.4	13.0	14.7	17.9	19.5	21.2
57	1.66	3.32	4.97	6.6	8.3	9.9	11.6	13.3	14.9	18.2	19.9	21.6
58	1.69	3.37	5.06	6.7	8.4	10.1	11.8	13.5	15.2	18.6	20.2	21.9
59	1.72	3.43	5.15	6.9	8.6	10.5	12.0	13.7	15.4	18.9	20.6	22.3
Horz. Dist.	99.99	199.9	299.9	399.9	499.9	599.9	699.9	799.9	899.9	1099.9	1199.9	1299.9

Hor. dist. is for 30′ point. Add or subtract .005 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES N ELEVATION

0°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	1
0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.3	1.4	1.4	1.5	2
1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	3
1.6	1.7	1.9	2.0	2.1	2.2	2.4	2.6	2.7	2.7	2.9	3.0	4
2.0	2.2	2.3	2.5	2.6	2.8	3.1	3.2	3.4	3.5	3.6	3.8	5
2.4	2.6	2.8	3.0	3.1	3.3	3.7	3.8	4.0	4.2	4.4	4.5	6
2.8	3.0	3.3	3.5	3.7	3.9	4.3	4.5	4.7	4.9	5.1	5.3	7
3.3	3.5	3.7	4.0	4.2	4.4	4.9	5.1	5.3	5.6	5.8	6.0	8
3.7	3.9	4.2	4.4	4.7	5.0	5.5	5.8	6.0	6.3	6.6	6.8	9
4.1	4.4	4.7	4.9	5.2	5.5	6.1	6.4	6.7	7.0	7.3	7.6	10
4.5	4.8	5.1	5.4	5.8	6.1	6.7	7.0	7.4	7.7	8.0	8.3	11
4.9	5.2	5.6	5.9	6.3	6.6	7.3	7.7	8.0	8.4	8.7	9.1	12
5.3	5.7	6.0	6.4	6.8	7.2	7.9	8.3	8.7	9.1	9.4	9.8	13
5.7	6.1	6.5	6.9	7.3	7.7	8.5	9.0	9.4	9.8	10.2	10.6	14
6.1	6.5	7.0	7.4	7.9	8.2	9.2	9.6	10.0	10.5	10.9	11.3	15
6.5	7.0	7.4	7.9	8.4	8.8	9.8	10.2	10.7	11.2	11.6	12.1	16
6.9	7.4	7.9	8.4	8.9	9.4	10.4	10.9	11.4	11.9	12.4	12.9	17
7.3	7.8	8.4	8.9	9.4	9.9	11.0	11.5	12.0	12.6	13.1	13.6	18
7.7	8.3	8.8	9.4	9.9	10.5	11.6	12.2	12.7	13.3	13.8	14.4	19
8.1	8.7	9.3	10.0	10.5	11.1	12.2	12.8	13.4	14.0	14.6	15.1	20
8.6	9.2	9.8	10.4	11.0	11.6	12.8	13.4	14.0	14.7	15.3	15.9	21
9.0	9.6	10.2	10.9	11.5	12.2	13.4	14.1	14.7	15.4	16.0	16.6	22
9.4	10.0	10.7	11.4	12.0	12.7	14.0	14.7	15.4	16.1	16.7	17.4	23
9.8	10.5	11.2	11.9	12.6	13.3	14.7	15.4	16.0	16.8	17.4	18.1	24
10.2	10.9	11.6	12.4	13.1	13.8	15.3	16.0	16.7	17.4	18.2	18.9	25
10.6	11.3	12.1	12.9	13.6	14.4	15.9	16.6	17.4	18.2	18.9	19.7	26
11.0	11.8	13.6	13.3	14.1	14.9	16.6	17.3	18.1	18.8	19.6	20.4	27
11.4	12.2	13.0	13.8	14.7	15.5	17.1	17.9	18.7	19.5	20.4	21.2	28
11.8	12.6	13.5	14.3	15.2	16.0	17.7	18.6	19.4	20.2	21.1	21.9	29
12.2	13.1	14.0	14.8	15.7	16.6	18.3	19.2	20.1	20.9	21.8	22.7	30
12.6	13.5	14.4	15.3	16.2	17.1	18.9	19.8	20.7	21.6	22.5	23.4	31
13.0	14.0	14.9	15.8	16.8	17.7	19.5	20.5	21.4	22.3	23.3	24.2	32
13.4	14.4	15.4	16.3	17.3	18.2	20.2	21.1	22.1	23.0	24.0	25.0	33
13.8	14.8	15.8	16.8	17.8	18.8	20.8	21.8	22.7	23.7	24.7	25.7	34
14.2	15.3	16.3	17.3	18.3	19.3	21.4	22.4	23.4	24.4	25.4	26.5	35
14.7	15.7	16.7	17.8	18.8	19.9	22.0	23.0	24.1	25.1	26.2	27.2	36
15.1	16.1	17.2	18.3	19.4	20.4	22.6	23.7	24.7	25.8	26.9	28.0	37
15.5	16.6	17.7	18.8	19.9	21.0	23.2	24.3	25.4	26.5	27.6	28.7	38
15.9	17.0	18.2	19.3	20.4	21.6	23.8	25.0	26.1	27.2	28.4	29.5	39
16.3	17.4	18.6	19.8	20.9	22.1	24.4	25.6	26.8	27.9	29.1	30.2	40
16.7	17.9	19.1	20.3	21.5	22.7	25.0	26.2	27.4	28.6	29.8	31.0	41
17.1	18.3	19.5	20.7	22.0	23.2	25.6	26.9	28.1	29.3	30.5	31.8	42
17.5	18.8	20.0	21.2	22.5	23.8	26.3	27.5	28.8	30.0	31.3	32.5	43
17.9	19.2	20.5	21.8	23.0	24.3	26.9	28.2	29.4	30.7	32.0	33.3	44
18.3	19.6	20.9	22.2	23.6	24.9	27.5	28.8	30.1	31.4	32.7	34.0	45
18.7	20.1	21.4	22.7	24.1	25.4	28.1	29.4	30.8	32.1	33.4	34.8	46
19.1	20.5	21.9	23.2	24.6	26.0	28.7	30.1	31.4	32.8	34.2	35.5	47
19.5	20.9	22.3	23.7	25.1	26.5	29.3	30.7	32.1	33.5	34.9	36.3	48
20.0	21.4	22.8	24.2	25.6	27.1	29.9	31.4	32.8	34.2	35.6	37.0	49
20.4	21.8	23.3	24.7	26.2	27.6	30.5	32.0	33.4	34.9	36.4	37.8	50
20.8	22.2	23.7	25.2	26.7	28.2	31.2	32.6	34.1	35.6	37.1	38.6	51
21.2	22.7	24.2	25.7	27.2	28.7	31.8	33.3	34.8	36.3	37.8	39.3	52
21.6	23.1	24.7	26.2	27.7	29.3	32.4	33.9	35.4	37.0	38.5	40.1	53
22.0	23.6	25.1	26.7	28.3	29.8	33.0	34.5	36.1	37.7	39.2	40.8	54
22.4	24.0	25.6	27.2	28.8	30.4	33.6	35.2	36.8	38.4	40.0	41.6	55
22.8	24.4	26.1	27.7	29.3	30.9	34.2	35.8	37.5	39.1	40.7	42.3	56
23.2	24.9	26.5	28.2	29.8	31.5	34.8	36.5	38.1	39.8	41.4	43.1	57
23.6	25.3	27.0	28.7	30.4	32.0	35.4	37.1	38.8	40.5	42.2	43.9	58
24.0	25.7	27.5	29.2	30.9	32.6	36.0	37.8	39.5	41.2	42.9	44.6	59
1399.9	1499.8	1599.8	1699.8	1799.8	1899.8	2099.8	2199.8	2299.8	2399.8	2499.8	2599.8	Hor. Dis.

Hor. dist. is for 30′ point. Add or subtract .005 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

1°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	1.74	3.49	5.24	7.0	8.7	10.5	12.2	14.0	15.7	19.2	20.9	22.7
1	1.77	3.55	5.32	7.1	8.9	10.6	12.4	14.2	16.0	19.5	21.3	23.1
2	1.80	3.61	5.41	7.2	9.0	10.8	12.6	14.4	16.2	19.8	21.6	23.4
3	1.83	3.66	5.50	7.3	9.2	11.0	12.8	14.7	16.5	20.1	22.0	23.8
4	1.86	3.72	5.58	7.4	9.3	11.2	13.0	14.9	16.7	20.5	22.3	24.2
5	1.89	3.78	5.67	7.6	9.4	11.3	13.2	15.1	17.0	20.8	22.7	24.6
6	1.92	3.84	5.76	7.7	9.6	11.5	13.4	15.4	17.3	21.1	23.0	24.9
7	1.95	3.90	5.84	7.8	9.7	11.7	13.6	15.6	17.5	21.4	23.4	25.3
8	1.98	3.96	5.93	7.9	9.9	11.9	13.8	15.8	17.8	21.7	23.7	25.7
9	2.01	4.01	6.02	8.0	10.0	12.0	14.0	16.0	18.1	22.1	24.1	26.1
10	2.04	4.07	6.11	8.1	10.2	12.2	14.2	16.3	18.3	22.4	24.4	26.5
11	2.06	4.13	6.19	8.3	10.3	12.4	14.4	16.5	18.6	22.7	24.8	26.8
12	2.09	4.19	6.28	8.4	10.5	12.6	14.7	16.7	18.8	23.0	25.1	27.2
13	2.12	4.25	6.37	8.5	10.6	12.7	14.9	17.0	19.1	23.3	25.5	27.6
14	2.15	4.30	6.46	8.6	10.8	12.9	15.1	17.2	19.4	23.7	25.8	28.0
15	2.18	4.36	6.54	8.7	10.9	13.1	15.3	17.4	19.6	24.0	26.2	28.4
16	2.21	4.42	6.63	8.8	11.0	13.3	15.5	17.7	19.9	24.3	26.5	28.7
17	2.24	4.48	6.72	9.0	11.2	13.4	15.7	17.9	20.2	24.6	26.9	29.1
18	2.27	4.54	6.80	9.1	11.3	13.6	15.9	18.1	20.4	24.9	27.2	29.5
19	2.30	4.59	6.89	9.2	11.5	13.8	16.1	18.4	20.7	25.3	27.6	29.9
20	2.33	4.65	6.98	9.3	11.6	14.0	16.3	18.6	20.9	25.6	27.9	30.2
21	2.36	4.71	7.07	9.4	11.8	14.1	16.5	18.8	21.2	25.9	28.3	30.6
22	2.38	4.77	7.15	9.5	11.9	14.3	16.7	19.1	21.5	26.2	28.6	31.0
23	2.41	4.83	7.24	9.6	12.1	14.5	16.9	19.3	21.7	26.5	29.0	31.4
24	2.44	4.88	7.33	9.8	12.2	14.7	17.1	19.5	22.0	26.9	29.3	31.8
25	2.47	4.94	7.41	9.9	12.4	14.8	17.3	19.8	22.2	27.2	29.7	32.1
26	2.50	5.00	7.50	10.0	12.5	15.0	17.5	20.0	22.5	27.5	30.0	32.5
27	2.53	5.06	7.59	10.1	12.6	15.2	17.7	20.2	22.8	27.8	30.3	32.9
28	2.56	5.12	7.68	10.2	12.8	15.4	17.9	20.5	23.0	28.1	30.7	33.3
29	2.59	5.18	7.76	10.4	12.9	15.5	18.1	20.7	23.3	28.5	31.0	33.6
30	2.62	5.23	7.85	10.5	13.1	15.7	18.3	20.9	23.6	28.8	31.4	34.0
31	2.65	5.29	7.94	10.6	13.2	15.9	18.5	21.2	23.8	29.1	31.8	34.4
32	2.68	5.35	8.02	10.7	13.4	16.0	18.7	21.4	24.1	29.4	32.1	34.8
33	2.70	5.41	8.11	10.8	13.5	16.2	18.9	21.6	24.3	29.7	32.4	35.2
34	2.73	5.47	8.20	10.9	13.7	16.4	19.1	21.9	24.6	30.1	32.8	35.5
35	2.76	5.52	8.29	11.0	13.8	16.6	19.3	22.1	24.9	30.4	33.1	35.9
36	2.79	5.58	8.37	11.2	14.0	16.7	19.5	22.3	25.1	30.7	33.5	36.3
37	2.82	5.64	8.46	11.3	14.1	16.9	19.7	22.6	25.4	31.0	33.8	36.7
38	2.85	5.70	8.55	11.4	14.2	17.1	19.9	22.8	25.6	31.3	34.2	37.0
39	2.88	5.76	8.63	11.5	14.4	17.3	20.1	23.0	25.9	31.7	34.5	37.4
40	2.91	5.81	8.72	11.6	14.5	17.4	20.3	23.3	26.2	32.0	34.9	37.8
41	2.94	5.87	8.81	11.8	14.7	17.6	20.6	23.5	26.4	32.3	35.2	38.2
42	2.97	5.93	8.90	11.9	14.8	17.8	20.8	23.7	26.7	32.6	35.6	38.6
43	3.00	5.99	8.98	12.0	15.0	18.0	21.0	24.0	27.0	32.9	35.9	38.9
44	3.02	6.05	9.07	12.1	15.1	18.1	21.2	24.2	27.2	33.3	36.3	39.3
45	3.05	6.10	9.16	12.2	15.3	18.3	21.4	24.4	27.5	33.6	36.6	39.7
46	3.08	6.16	9.24	12.3	15.4	18.5	21.6	24.6	27.7	33.9	37.0	40.1
47	3.11	6.22	9.33	12.4	15.6	18.7	21.8	24.9	28.0	34.2	37.3	40.4
48	3.14	6.28	9.42	12.6	15.7	18.8	22.0	25.1	28.3	34.5	37.7	40.8
49	3.17	6.34	9.50	12.7	15.8	19.0	22.2	25.3	28.5	34.8	38.0	41.2
50	3.20	6.40	9.59	12.8	16.0	19.2	22.4	25.6	28.8	35.2	38.4	41.6
51	3.23	6.45	9.68	12.9	16.1	19.4	22.6	25.8	29.0	35.5	38.7	41.9
52	3.26	6.51	9.77	13.0	16.3	19.5	22.8	26.0	29.3	35.8	39.1	42.3
53	3.29	6.57	9.85	13.1	16.4	19.7	23.0	26.3	29.6	36.1	39.4	42.7
54	3.31	6.63	9.94	13.2	16.6	19.9	23.2	26.5	29.8	36.4	39.8	43.1
55	3.34	6.68	10.03	13.4	16.7	20.1	23.4	26.7	30.1	36.8	40.1	43.4
56	3.37	6.74	10.11	13.5	16.9	20.2	23.6	27.0	30.3	37.1	40.5	43.8
57	3.40	6.80	10.20	13.6	17.0	20.4	23.8	27.2	30.6	37.4	40.8	44.2
58	3.43	6.86	10.29	13.7	17.2	20.6	24.0	27.4	30.9	37.7	41.2	44.6
59	3.46	6.92	10.38	13.8	17.3	20.7	24.2	27.7	31.1	38.0	41.5	45.0
Horz. Dist.	99.93	199.9	299.8	399.7	499.6	599	699	799	899	1099	1199	1299

Hor. dist. is for 30′ point. Add or subtract .015 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

1°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
24.4	26.2	27.9	29.7	31.4	33.2	36.6	38.4	40.1	41.9	43.6	45.4	0
24.8	26.6	28.4	30.2	31.9	33.7	37.2	39.0	40.8	42.6	44.4	46.1	1
25.2	27.0	28.8	30.6	32.4	34.3	37.9	39.7	41.5	43.3	45.1	46.9	2
25.6	27.5	29.3	31.1	33.0	34.8	38.5	40.3	42.1	44.0	45.8	47.6	3
26.1	27.9	29.8	31.6	33.5	35.4	39.1	40.9	42.8	44.7	46.5	48.4	4
26.5	28.4	30.2	32.1	34.0	35.9	39.7	41.6	43.5	45.4	47.3	49.1	5
26.8	28.8	30.7	32.6	34.5	36.5	40.3	42.2	44.1	46.1	48.0	49.9	6
27.3	29.2	31.2	33.1	35.1	37.0	40.9	42.9	44.8	46.7	48.7	50.6	7
27.7	29.7	31.6	33.6	35.6	37.6	41.5	43.5	45.5	47.5	49.4	51.4	8
28.1	30.1	32.1	34.1	36.1	38.1	42.1	44.1	46.1	48.2	50.2	52.2	9
28.5	30.5	32.6	34.6	36.6	38.7	42.7	44.8	46.8	48.8	50.9	52.9	10
28.9	31.0	33.0	35.1	37.2	39.2	43.3	45.4	47.5	49.5	51.6	53.7	11
29.3	31.4	33.5	35.6	37.7	39.8	44.0	46.1	48.2	50.3	52.4	54.4	12
29.7	31.8	34.0	36.1	38.2	40.3	44.6	46.7	48.8	50.9	53.1	55.2	13
30.1	32.3	34.4	36.6	38.7	40.9	45.2	47.3	49.5	51.6	53.8	55.9	14
30.5	32.7	34.9	37.1	39.3	41.4	45.8	48.0	50.2	52.3	54.5	56.7	15
30.9	33.2	35.4	37.6	39.8	42.0	46.4	48.6	50.8	53.0	55.2	57.5	16
31.3	33.6	35.8	38.1	40.3	42.5	47.0	49.3	51.5	53.7	56.0	58.2	17
31.7	34.0	36.3	38.6	40.8	43.1	47.6	49.9	52.2	54.4	56.7	59.0	18
32.2	34.5	36.8	39.0	41.3	43.6	48.2	50.5	52.8	55.1	57.4	59.7	19
32.6	34.9	37.2	39.6	41.9	44.2	48.9	51.2	53.5	55.8	58.2	60.5	20
33.0	35.3	37.7	40.0	42.4	44.8	49.5	51.8	54.2	56.5	58.9	61.2	21
33.4	35.8	38.1	40.5	42.9	45.3	50.1	52.5	54.8	57.2	59.6	62.0	22
33.8	36.2	38.6	41.0	43.4	45.9	50.7	53.1	55.5	57.9	60.3	62.8	23
34.2	36.6	39.1	41.5	44.0	46.4	51.3	53.7	56.2	58.6	61.1	63.5	24
34.6	37.1	39.5	42.0	44.5	47.0	51.9	54.4	56.8	59.3	61.8	64.3	25
35.0	37.5	40.0	42.5	45.0	47.5	52.5	55.0	57.5	60.0	62.5	65.0	26
35.4	37.9	40.5	43.0	45.5	48.1	53.1	55.6	58.2	60.7	63.2	65.8	27
35.8	38.4	40.9	43.5	46.0	48.6	53.7	56.3	58.8	61.4	64.0	66.5	28
36.2	38.8	41.4	44.0	46.6	49.2	54.3	56.9	59.5	62.1	64.7	67.3	29
36.6	39.3	41.9	44.5	47.1	49.7	55.0	57.6	60.2	62.8	65.4	68.0	30
37.0	39.7	42.3	45.0	47.6	50.3	55.6	58.2	60.9	63.5	66.2	68.8	31
37.4	40.1	42.8	45.5	48.2	50.8	56.2	58.8	61.5	64.2	66.9	69.6	32
37.9	40.6	43.3	46.0	48.7	51.4	56.8	59.5	62.2	64.9	67.6	70.3	33
38.3	41.0	43.7	46.5	49.2	51.9	57.4	60.1	62.9	65.6	68.3	71.1	34
38.7	41.4	44.2	47.0	49.7	52.5	58.0	60.8	63.5	66.3	69.0	71.8	35
39.1	41.9	44.7	47.4	50.2	53.0	58.6	61.4	64.2	67.0	69.8	72.6	36
39.5	42.3	45.1	47.9	50.8	53.6	59.2	62.0	64.9	67.7	70.5	73.3	37
39.9	42.7	45.6	48.4	51.3	54.1	59.8	62.7	65.5	68.4	71.2	74.1	38
40.3	43.2	46.0	48.9	51.8	54.7	60.4	63.3	66.2	69.1	72.0	74.8	39
40.7	43.6	46.5	49.4	52.3	55.2	61.0	64.0	66.9	69.8	72.7	75.6	40
41.1	44.0	47.0	49.9	52.9	55.8	61.7	64.6	67.5	70.5	73.4	76.3	41
41.5	44.5	47.4	50.4	53.4	56.3	62.3	65.2	68.2	71.2	74.1	77.1	42
41.9	44.9	47.9	50.9	53.9	56.9	62.9	65.9	68.9	71.9	74.9	77.9	43
42.3	45.3	48.4	51.4	54.4	57.4	63.5	66.5	69.5	72.6	75.6	78.6	44
42.7	45.8	48.8	51.9	54.9	58.0	64.1	67.2	70.2	73.3	76.3	79.4	45
43.1	46.2	49.3	52.4	55.5	58.5	64.7	67.8	70.9	74.0	77.0	80.1	46
43.5	46.7	49.8	52.9	56.0	59.1	65.3	68.4	71.5	74.6	77.8	80.9	47
43.9	47.1	50.2	53.4	56.5	59.7	65.9	69.1	72.2	75.3	78.5	81.6	48
44.4	47.5	50.7	53.9	57.0	60.2	66.5	69.7	72.9	76.0	79.2	82.4	49
44.8	48.0	51.2	54.4	57.6	60.8	67.1	70.3	73.5	76.7	80.0	83.1	50
45.2	48.4	51.6	54.8	58.1	61.3	67.8	71.0	74.2	77.4	80.7	83.9	51
45.6	48.8	52.1	55.3	58.6	61.8	68.4	71.6	74.9	78.1	81.4	84.6	52
46.0	49.3	52.6	55.8	59.1	62.4	69.0	72.3	75.5	78.8	82.1	85.4	53
46.4	49.7	53.0	56.3	59.6	63.0	69.6	72.9	76.2	79.5	82.8	86.2	54
46.8	50.1	53.5	56.8	60.2	63.5	70.2	73.5	76.9	80.2	83.6	86.9	55
47.2	50.6	53.9	57.3	60.7	64.1	70.8	74.2	77.6	80.9	84.3	87.7	56
47.6	51.0	54.4	57.8	61.2	64.6	71.4	74.8	78.2	81.6	85.0	88.4	57
48.0	51.5	54.9	58.3	61.7	65.2	72.0	75.5	78.9	82.3	85.8	89.1	58
48.4	51.9	55.3	58.8	62.3	65.7	72.6	76.1	79.6	83.0	86.5	89.9	59
1399	1499	1599	1699	1799	1899	2098	2198	2298	2398	2498	2598	Hor. Dist.

Hor. dist. is for 30′ point. Add or subtract .015 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

2°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	3.49	6.98	10.46	14.0	17.4	20.9	24.4	27.9	31.4	38.4	41.9	45.3
1	3.52	7.03	10.55	14.1	17.6	21.1	24.6	28.1	31.7	38.7	42.2	45.7
2	3.55	7.09	10.64	14.2	17.7	21.3	24.8	28.4	31.9	39.0	42.6	46.1
3	3.58	7.15	10.72	14.3	17.9	21.4	25.0	28.6	32.2	39.3	42.9	46.5
4	3.60	7.21	10.81	14.4	18.0	21.6	25.2	28.8	32.4	39.6	43.2	46.8
5	3.63	7.27	10.90	14.5	18.2	21.8	25.4	29.1	32.7	40.0	43.6	47.2
6	3.66	7.32	10.99	14.6	18.3	22.0	25.6	29.3	33.0	40.3	43.9	47.6
7	3.69	7.38	11.07	14.8	18.5	22.1	25.8	29.5	33.2	40.6	44.3	48.0
8	3.72	7.44	11.16	14.9	18.6	22.3	26.0	29.8	33.5	40.9	44.6	48.4
9	3.75	7.50	11.25	15.0	18.7	22.5	26.2	30.0	33.7	41.2	45.0	48.7
10	3.78	7.56	11.33	15.1	18.9	22.7	26.4	30.2	34.0	41.6	45.3	49.1
11	3.81	7.61	11.42	15.2	19.0	22.8	26.6	30.5	34.3	41.9	45.7	49.5
12	3.84	7.67	11.51	15.3	19.2	23.0	26.8	30.7	34.5	42.2	46.0	49.9
13	3.86	7.73	11.60	15.5	19.3	23.2	27.1	30.9	34.8	42.5	46.4	50.2
14	3.89	7.79	11.68	15.6	19.5	23.4	27.3	31.1	35.0	42.8	46.7	50.6
15	3.92	7.85	11.77	15.7	19.6	23.5	27.5	31.4	35.3	43.1	47.1	51.0
16	3.95	7.90	11.86	15.8	19.8	23.7	27.7	31.6	35.6	43.5	47.4	51.4
17	3.98	7.96	11.94	15.9	19.9	23.9	27.9	31.8	35.8	43.8	47.8	51.7
18	4.01	8.02	12.03	16.0	20.0	24.1	28.1	32.1	36.1	44.1	48.1	52.1
19	4.04	8.08	12.12	16.2	20.2	24.2	28.3	32.3	36.3	44.4	48.5	52.5
20	4.07	8.14	12.20	16.3	20.3	24.4	28.5	32.5	36.6	44.7	48.8	52.9
21	4.10	8.19	12.29	16.4	20.5	24.6	28.7	32.8	36.9	45.1	49.2	53.3
22	4.13	8.25	12.38	16.5	20.6	24.8	28.9	33.0	37.1	45.4	49.5	53.6
23	4.16	8.31	12.46	16.6	20.8	24.9	29.1	33.2	37.4	45.7	49.9	54.0
24	4.18	8.37	12.55	16.7	20.9	25.1	29.3	33.5	37.7	46.0	50.2	54.4
25	4.21	8.43	12.64	16.8	21.1	25.3	29.5	33.7	37.9	46.3	50.6	54.8
26	4.24	8.48	12.73	17.0	21.2	25.4	29.7	33.9	38.2	46.7	50.9	55.1
27	4.27	8.54	12.81	17.1	21.4	25.6	29.9	34.2	38.4	47.0	51.2	55.5
28	4.30	8.60	12.90	17.2	21.5	25.8	30.1	34.4	38.7	47.3	51.6	55.9
29	4.33	8.66	12.99	17.3	21.6	26.0	30.3	34.6	39.0	47.6	51.9	56.3
30	4.36	8.716	13.07	17.4	21.8	26.1	30.5	34.9	39.2	47.9	52.3	56.6
31	4.39	8.774	13.16	17.5	21.9	26.3	30.7	35.1	39.5	48.3	52.6	57.0
32	4.42	8.831	13.25	17.7	22.1	26.5	30.9	35.3	39.7	48.6	53.0	57.4
33	4.44	8.889	13.33	17.8	22.2	26.7	31.1	35.6	40.0	48.9	53.3	57.8
34	4.47	8.947	13.42	17.9	22.4	26.8	31.3	35.8	40.3	49.2	53.7	58.2
35	4.50	9.005	13.51	18.0	22.5	27.0	31.5	36.0	40.5	49.5	54.0	58.5
36	4.53	9.063	13.59	18.1	22.7	27.2	31.7	36.2	40.8	49.8	54.4	58.9
37	4.56	9.121	13.68	18.2	22.8	27.4	31.9	36.5	41.0	50.2	54.7	59.3
38	4.59	9.179	13.77	18.4	22.9	27.5	32.1	36.7	41.3	50.5	55.1	59.7
39	4.62	9.237	13.86	18.5	23.1	27.7	32.3	36.9	41.6	50.8	55.4	60.0
40	4.65	9.295	13.94	18.6	23.2	27.9	32.5	37.2	41.8	51.1	55.8	60.4
41	4.68	9.353	14.03	18.7	23.4	28.1	32.7	37.4	42.1	51.4	56.1	60.8
42	4.71	9.411	14.12	18.8	23.5	28.2	32.9	37.6	42.3	51.8	56.5	61.2
43	4.73	9.469	14.20	18.9	23.7	28.4	33.1	37.9	42.6	52.1	56.8	61.5
44	4.76	9.527	14.29	19.0	23.8	28.6	33.3	38.1	42.9	52.4	57.2	61.9
45	4.79	9.585	14.38	19.2	24.0	28.8	33.5	38.3	43.1	52.7	57.5	62.3
46	4.82	9.642	14.46	19.3	24.1	28.9	33.7	38.6	43.4	53.0	57.8	62.7
47	4.85	9.700	14.55	19.4	24.2	29.1	34.0	38.8	43.6	53.4	58.2	63.0
48	4.88	9.758	14.64	19.5	24.4	29.3	34.1	39.0	43.9	53.7	58.5	63.4
49	4.91	9.816	14.72	19.6	24.5	29.4	34.4	39.3	44.2	54.0	58.9	63.8
50	4.94	9.874	14.81	19.7	24.7	29.6	34.6	39.5	44.4	54.3	59.2	64.2
51	4.97	9.932	14.90	19.9	24.8	29.8	34.8	39.7	44.7	54.6	59.6	64.6
52	5.00	9.990	14.98	20.0	25.0	30.0	35.0	40.0	45.0	54.9	59.9	64.9
53	5.02	10.048	15.07	20.1	25.1	30.1	35.2	40.2	45.2	55.3	60.3	65.3
54	5.05	10.106	15.16	20.2	25.3	30.3	35.4	40.4	45.5	55.6	60.6	65.7
55	5.08	10.164	15.25	20.3	25.4	30.5	35.6	40.7	45.7	55.9	61.0	66.1
56	5.11	10.222	15.33	20.4	25.6	30.7	35.8	40.9	46.0	56.2	61.3	66.4
57	5.14	10.280	15.42	20.6	25.7	30.8	36.0	41.1	46.3	56.5	61.7	66.8
58	5.17	10.338	15.51	20.7	25.8	31.0	36.2	41.3	46.5	56.8	62.0	67.2
59	5.20	10.396	15.59	20.8	26.0	31.2	36.4	41.6	46.8	57.2	62.4	67.6
Horz. Dist.	99.81	199.6	299.4	399.2	499.0	599	699	798	898	1098	1198	1297

Hor. dist. is for 30′ point. Add or subtract .025 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

2°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
48.8	52.3	55.8	59.3	62.8	66.3	73.2	76.7	80.2	83.7	87.2	90.7	0
49.2	52.8	56.3	59.8	63.3	66.8	73.9	77.4	80.9	84.4	87.9	91.4	1
49.6	53.2	56.7	60.3	63.8	67.4	74.5	78.0	81.6	85.1	88.6	92.2	2
50.0	53.6	57.2	60.8	64.4	67.9	75.1	78.6	82.2	85.8	89.4	93.0	3
50.5	54.1	57.7	61.3	64.9	68.8	75.7	79.3	82.9	86.5	90.1	93.7	4
50.9	54.5	58.1	61.8	65.4	69.0	76.3	79.9	83.6	87.2	90.8	94.5	5
51.3	54.9	58.6	62.2	65.9	69.6	76.9	80.6	84.2	87.9	91.6	95.2	6
51.7	55.4	59.1	62.7	66.4	70.1	77.5	81.2	84.9	88.6	92.3	96.0	7
52.1	55.8	59.5	63.2	67.0	70.7	78.1	81.8	85.6	89.3	93.0	96.7	8
52.5	56.2	60.0	63.7	67.5	71.2	78.7	82.5	86.2	90.0	93.7	97.5	9
52.9	56.7	60.4	64.2	68.0	71.8	79.3	83.1	86.9	90.7	94.5	98.2	10
53.3	57.1	60.9	64.7	68.5	72.3	79.9	83.7	87.6	91.4	95.2	99.0	11
53.7	57.5	61.4	65.2	69.0	72.9	80.6	84.4	88.2	92.0	95.9	99.7	12
54.1	58.0	61.8	65.7	69.6	73.4	81.2	85.0	88.9	92.8	96.6	100.5	13
54.5	58.4	62.3	66.2	70.1	74.0	81.8	85.7	89.6	93.5	97.4	101.2	14
54.9	58.8	62.8	66.7	70.6	74.5	82.4	86.3	90.2	94.1	98.1	102.0	15
55.3	59.3	63.2	67.2	71.1	75.1	83.0	86.9	90.9	94.8	98.8	102.7	16
55.7	59.7	63.7	67.7	71.7	75.6	83.6	87.6	91.6	95.5	99.5	103.5	17
56.1	60.2	64.2	68.2	72.7	76.2	84.2	88.2	92.2	96.2	100.2	104.3	18
56.5	60.6	64.6	68.7	72.7	76.7	84.8	88.9	92.9	96.9	101.0	105.0	19
56.9	61.0	65.1	69.2	73.2	77.3	85.4	89.5	93.6	97.6	101.7	105.8	20
57.4	61.5	65.6	69.6	73.7	77.8	86.0	90.1	94.2	98.3	102.4	106.5	21
57.8	61.9	66.0	70.1	74.3	78.4	86.6	90.8	94.9	99.0	103.2	107.3	22
58.2	62.3	66.5	70.6	74.8	78.9	87.3	91.4	95.6	99.7	103.9	108.0	23
58.6	62.8	66.9	71.1	75.3	79.5	87.9	92.0	96.2	100.4	104.6	108.8	24
59.0	63.2	67.4	71.6	75.8	80.0	88.5	92.7	96.9	101.1	105.3	109.5	25
59.4	63.6	67.9	72.1	76.4	80.6	89.1	93.3	97.6	101.8	106.0	110.3	26
59.8	64.1	68.3	72.6	76.9	81.1	89.7	94.0	98.2	102.5	106.8	111.0	27
60.2	64.5	68.8	73.1	77.4	81.7	90.3	94.6	98.9	103.2	107.5	111.8	28
60.6	64.9	69.3	73.6	77.9	82.2	90.9	95.3	99.6	103.9	108.2	112.5	29
61.0	65.4	69.7	74.1	78.4	82.8	91.5	95.9	100.2	104.6	109.0	113.3	30
61.4	65.8	70.2	74.6	79.0	83.3	92.1	96.5	100.9	105.3	109.7	114.1	31
61.8	66.2	70.6	75.1	79.5	83.9	92.7	97.1	101.6	106.0	110.4	114.8	32
62.2	66.7	71.1	75.6	80.0	84.4	93.3	97.8	102.2	106.7	111.1	115.6	33
62.6	67.1	71.6	76.0	80.5	85.0	93.9	98.4	102.9	107.4	111.8	116.3	34
63.0	67.5	72.0	76.5	81.0	85.5	94.6	99.1	103.6	108.1	112.6	117.1	35
63.4	68.0	72.5	77.1	81.6	86.1	95.2	99.7	104.2	108.8	113.3	117.8	36
63.8	68.4	73.0	77.5	82.1	86.7	95.8	100.3	104.9	109.5	114.0	118.6	37
64.2	68.8	73.4	78.0	82.6	87.2	96.4	101.0	105.6	110.1	114.7	119.3	38
64.7	69.3	73.9	78.5	83.1	87.8	97.0	101.6	106.2	110.9	115.5	120.1	39
65.1	69.7	74.4	79.0	83.7	88.3	97.6	102.2	106.9	111.5	116.2	120.8	40
65.5	70.1	74.8	79.5	84.2	88.9	98.2	102.9	107.6	112.2	116.9	121.6	41
65.9	70.6	75.3	80.0	84.7	89.4	98.8	103.5	108.2	112.9	117.6	122.3	42
66.3	71.0	75.8	80.5	85.2	90.0	99.4	104.2	108.9	113.6	118.4	123.1	43
66.7	71.4	76.3	81.0	85.7	90.5	100.0	104.8	109.6	114.3	119.1	123.8	44
67.1	71.9	76.7	81.5	86.3	91.1	100.6	105.4	110.2	115.0	119.8	124.6	45
67.5	72.3	77.1	82.0	86.8	91.6	101.2	106.1	110.9	115.7	120.5	125.3	46
67.9	72.8	77.6	82.4	87.3	92.2	101.8	106.7	111.6	116.4	121.2	126.1	47
68.3	73.2	78.1	82.9	87.8	92.7	102.5	107.3	112.2	117.1	122.0	126.8	48
68.7	73.6	78.5	83.4	88.3	93.2	103.1	108.0	112.9	117.8	122.7	127.6	49
69.1	74.1	79.0	83.9	88.9	93.8	103.7	108.6	113.6	118.5	123.4	128.4	50
69.5	74.5	79.5	84.4	89.4	94.3	104.3	109.3	114.2	119.2	124.2	129.1	51
69.9	74.9	79.9	84.9	89.9	94.9	104.9	109.9	114.9	119.9	124.9	129.9	52
70.3	75.4	80.4	85.4	90.4	95.5	105.5	110.5	115.6	120.6	125.6	130.6	53
70.7	75.8	80.8	85.9	90.9	96.0	106.1	111.2	116.2	121.3	126.3	131.4	54
71.1	76.2	81.3	86.4	91.5	96.6	106.7	111.8	116.9	122.0	127.0	132.1	55
71.5	76.7	81.8	86.9	92.0	97.1	107.3	112.4	117.5	122.6	127.8	132.9	56
71.9	77.1	82.2	87.4	92.5	97.7	107.9	113.1	118.2	123.3	128.5	133.6	57
72.4	77.5	82.7	87.9	93.0	98.2	108.5	113.7	118.9	124.0	129.2	134.4	58
72.8	78.0	83.2	88.4	93.6	98.7	109.1	114.3	119.5	124.7	129.9	135.1	59
1397	1497	1597	1697	1797	1896	2096	2196	2296	2395	2495	2595	Hor. Dist.

Hor. dist. is for 30′ point. Add or subtract .025 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

3°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	5.23	10.46	15.68	20.9	26.1	31.4	36.6	41.8	47.0	57.5	62.7	67.9
1	5.26	10.51	15.77	21.0	26.3	31.5	36.8	42.0	47.3	57.8	63.1	68.3
2	5.29	10.57	15.85	21.1	26.4	31.7	37.0	42.3	47.6	58.1	63.4	68.7
3	5.31	10.63	15.94	21.3	26.6	31.9	37.2	42.5	47.8	58.4	63.8	69.1
4	5.34	10.68	16.03	21.4	26.7	32.0	37.4	42.7	48.1	58.7	64.1	69.4
5	5.37	10.74	16.11	21.5	26.9	32.2	37.6	43.0	48.3	59.1	64.4	69.8
6	5.40	10.80	16.20	21.6	27.0	32.4	37.8	43.2	48.6	59.4	64.8	70.2
7	5.43	10.86	16.29	21.7	27.1	32.6	38.0	43.4	48.9	59.7	65.1	70.6
8	5.46	10.92	16.37	21.8	27.3	32.7	38.2	43.7	49.1	60.0	65.5	71.0
9	5.49	10.97	16.46	21.9	27.4	32.9	38.4	43.9	49.4	60.4	65.8	71.3
10	5.52	11.03	16.55	22.1	27.6	33.1	38.6	44.1	49.6	60.7	66.2	71.7
11	5.54	11.10	16.63	22.2	27.7	33.3	38.8	44.4	49.9	61.0	66.5	72.1
12	5.58	11.15	16.72	22.3	27.9	33.4	39.0	44.6	50.2	61.3	66.9	72.5
13	5.60	11.20	16.81	22.4	28.0	33.6	39.2	44.8	50.4	61.6	67.2	72.8
14	5.63	11.26	16.89	22.5	28.2	33.8	39.4	45.0	50.7	61.9	67.6	73.2
15	5.66	11.32	16.98	22.6	28.3	34.0	39.6	45.3	50.9	62.3	67.9	73.6
16	5.69	11.38	17.07	22.8	28.4	34.1	39.8	45.5	51.2	62.6	68.3	74.0
17	5.72	11.44	17.15	22.9	28.6	34.3	40.0	45.7	51.5	62.9	68.6	74.3
18	5.75	11.49	17.24	23.0	28.7	34.5	40.2	46.0	51.7	63.2	69.0	74.7
19	5.77	11.55	17.33	23.1	28.9	34.7	40.4	46.2	52.0	63.5	69.3	75.1
20	5.80	11.61	17.41	23.2	29.0	34.8	40.6	46.4	52.2	63.8	69.6	75.5
21	5.83	11.67	17.50	23.3	29.2	35.0	40.8	46.7	52.5	64.2	70.0	75.8
22	5.86	11.72	17.59	23.4	29.3	35.2	41.0	46.9	52.8	64.5	70.4	76.2
23	5.89	11.78	17.67	23.6	29.5	35.3	41.2	47.1	53.0	64.8	70.7	76.6
24	5.92	11.84	17.76	23.7	29.6	35.5	41.4	47.4	53.3	65.1	71.0	77.0
25	5.95	11.90	17.85	23.8	29.7	35.7	41.6	47.6	53.5	65.4	71.4	77.3
26	5.98	11.96	17.93	23.9	29.9	35.9	41.8	47.8	53.8	65.8	71.7	77.7
27	6.01	12.01	18.02	24.0	30.0	36.0	42.0	48.1	54.1	66.1	72.1	78.1
28	6.04	12.07	18.11	24.1	30.2	36.2	42.2	48.3	54.3	66.4	72.4	78.5
29	6.06	12.13	18.19	24.3	30.3	36.4	42.4	48.5	54.6	66.7	72.8	78.8
30	6.09	12.19	18.28	24.4	30.5	36.6	42.7	48.7	54.8	67.0	73.1	79.2
31	6.12	12.24	18.37	24.5	30.6	36.7	42.9	49.0	55.1	67.3	73.5	79.6
32	6.15	12.30	18.45	24.6	30.8	36.9	43.1	49.2	55.4	67.7	73.8	80.0
33	6.18	12.36	18.54	24.7	30.9	37.1	43.3	49.4	55.6	68.0	74.2	80.3
34	6.21	12.42	18.63	24.8	31.0	37.2	43.5	49.7	55.9	68.3	74.5	80.7
35	6.24	12.48	18.71	25.0	31.2	37.4	43.7	49.9	56.1	68.6	74.9	81.1
36	6.27	12.53	18.80	25.1	31.3	37.6	43.9	50.1	56.4	68.9	75.2	81.5
37	6.30	12.59	18.89	25.2	31.5	37.8	44.1	50.4	56.7	69.2	75.5	81.8
38	6.32	12.65	18.97	25.3	31.6	37.9	44.3	50.6	56.9	69.6	75.9	82.2
39	6.35	12.71	19.06	25.4	31.8	38.1	44.5	50.8	57.2	69.9	76.2	82.6
40	6.38	12.76	19.15	25.5	31.9	38.3	44.7	51.1	57.4	70.2	76.6	83.0
41	6.41	12.82	19.23	25.6	32.1	38.5	44.9	51.3	57.7	70.5	76.9	83.3
42	6.44	12.88	19.32	25.8	32.2	38.6	45.1	51.5	58.0	70.8	77.3	83.7
43	6.47	12.94	19.41	25.9	32.3	38.8	45.3	51.7	58.2	71.1	77.6	84.1
44	6.50	13.00	19.49	26.0	32.5	39.0	45.5	52.0	58.5	71.5	78.0	84.5
45	6.53	13.05	19.58	26.1	32.6	39.2	45.7	52.2	58.7	71.8	78.3	84.8
46	6.56	13.11	19.66	26.2	32.8	39.3	45.9	52.4	59.0	72.1	78.7	85.2
47	6.59	13.17	19.75	26.3	32.9	39.5	46.1	52.7	59.3	72.4	79.0	85.6
48	6.61	13.23	19.84	26.4	33.1	39.7	46.3	52.9	59.5	72.7	79.4	86.0
49	6.64	13.28	19.92	26.6	33.2	39.8	46.5	53.1	59.8	73.1	79.7	86.3
50	6.67	13.34	20.01	26.7	33.4	40.0	46.7	53.4	60.0	73.4	80.0	86.7
51	6.70	13.40	20.10	26.8	33.5	40.2	46.9	53.6	60.3	73.7	80.4	87.1
52	6.73	13.46	20.18	26.9	33.6	40.4	47.1	53.8	60.6	74.0	80.7	87.5
53	6.76	13.51	20.27	27.0	33.8	40.5	47.3	54.1	60.8	74.3	81.1	87.8
54	6.79	13.57	20.36	27.1	33.9	40.7	47.5	54.3	61.1	74.6	81.4	88.2
55	6.81	13.63	20.44	27.3	34.1	40.9	47.7	54.5	61.3	75.0	81.8	88.6
56	6.85	13.69	20.53	27.4	34.2	41.1	47.9	54.7	61.6	75.3	82.1	89.0
57	6.88	13.74	20.62	27.5	34.4	41.2	48.1	55.0	61.8	75.6	82.5	89.3
58	6.90	13.80	20.70	27.6	34.5	41.4	48.3	55.2	62.1	75.9	82.8	89.7
59	6.93	13.86	20.79	27.7	34.6	41.6	48.5	55.4	62.4	76.2	83.2	90.1
Horz Dist.	99.63	199.3	298.9	398.5	498.1	598	697	797	897	1096	1196	1295

Hor. dist. is for 30′ point. Add or subtract .035 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

3°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
73.2	78.4	83.6	88.8	94.1	99.3	109.8	115.0	120.2	125.4	130.7	135.9	0
73.6	78.8	84.1	89.3	94.6	99.9	110.4	115.6	120.9	126.1	131.4	136.6	1
74.0	79.3	84.6	89.8	95.1	100.4	111.0	116.3	121.5	126.8	132.1	137.4	2
74.4	79.7	85.0	90.4	95.6	100.9	111.6	116.9	122.2	127.5	132.8	138.1	3
74.8	80.1	85.5	90.8	96.2	101.5	112.2	117.5	122.9	128.2	133.6	138.9	4
75.2	80.6	85.9	91.3	96.7	102.0	112.8	118.2	123.5	128.9	134.3	139.6	5
75.6	81.0	86.4	91.8	97.2	102.6	113.4	118.8	124.2	129.6	135.0	140.4	6
76.0	81.4	86.9	92.3	97.7	103.2	114.0	119.4	124.9	130.3	135.7	141.2	7
76.4	81.9	87.3	92.8	98.2	103.7	114.6	120.1	125.5	131.0	136.4	141.9	8
76.8	82.3	87.8	93.3	98.8	104.2	115.2	120.7	126.2	131.7	137.2	142.6	9
77.2	82.7	88.2	93.8	99.3	104.9	115.8	121.3	126.9	132.4	137.9	143.4	10
77.6	83.2	88.7	94.3	99.8	105.3	116.4	122.0	127.5	133.1	138.6	144.2	11
78.0	83.6	89.2	94.7	100.3	105.9	117.0	122.6	128.2	133.8	139.3	144.9	12
78.4	84.0	89.6	95.2	100.8	106.4	117.6	123.3	128.9	134.5	140.1	145.7	13
78.8	84.5	90.1	95.7	101.4	107.0	118.3	123.9	129.5	135.2	140.8	146.4	14
79.2	84.9	90.6	96.2	101.9	107.5	118.9	124.5	130.2	135.8	141.5	147.2	15
79.6	85.3	91.0	96.7	102.4	108.1	119.5	125.2	130.8	136.5	142.2	147.9	16
80.0	85.8	91.5	97.2	102.9	108.6	120.1	125.8	131.5	137.2	143.0	148.7	17
80.5	86.2	92.0	97.7	103.4	109.2	120.7	126.4	132.2	137.9	143.7	149.4	18
80.9	86.6	92.4	98.2	104.0	109.7	121.3	127.1	132.9	138.6	144.4	150.2	19
81.3	87.1	92.9	98.7	104.4	110.3	121.9	127.7	133.5	139.3	145.1	150.9	20
81.7	87.5	93.3	99.2	105.0	110.8	122.5	128.3	134.2	140.0	145.8	151.7	21
82.1	87.9	93.8	99.7	105.5	111.4	123.1	129.0	134.9	140.7	146.6	152.4	22
82.5	88.4	94.3	100.2	106.0	111.9	123.7	129.6	135.5	141.4	147.3	153.2	23
82.9	88.8	94.7	100.6	106.6	112.5	124.3	130.2	136.2	142.1	148.0	153.9	24
83.3	89.2	95.2	101.1	107.1	113.0	124.9	130.9	136.8	142.7	148.7	154.7	25
83.7	89.7	95.6	101.6	107.6	113.6	125.5	131.5	137.5	143.5	149.4	155.4	26
84.1	90.1	96.1	102.1	108.1	114.1	126.1	132.2	138.2	144.2	150.2	156.2	27
84.5	90.5	96.6	102.6	108.6	114.7	126.7	132.8	138.8	144.8	150.9	156.9	28
84.9	91.0	97.0	103.1	109.2	115.2	127.4	133.4	139.5	145.5	151.6	157.7	29
85.3	91.4	97.5	103.6	109.7	115.8	128.0	134.1	140.2	146.2	152.3	158.4	30
85.7	91.8	98.0	104.1	110.2	116.3	128.6	134.7	140.8	146.9	153.1	159.2	31
86.1	92.3	98.4	104.6	110.7	116.9	129.2	135.3	141.5	147.6	153.8	159.9	32
86.5	92.7	98.9	105.1	111.2	117.4	129.8	136.0	142.1	148.3	154.5	160.7	33
86.9	93.1	99.3	105.6	111.8	118.0	130.4	136.6	142.8	149.0	155.2	161.4	34
87.3	93.6	99.8	106.0	112.3	118.5	131.0	137.2	143.5	149.7	156.0	162.2	35
87.7	94.0	100.3	106.5	112.8	119.1	131.6	137.9	144.1	150.4	156.7	162.9	36
88.1	94.4	100.7	107.0	113.3	119.6	132.2	138.5	144.8	151.1	157.4	163.7	37
88.5	94.8	101.2	107.5	113.8	120.2	132.8	139.1	145.5	151.8	158.1	164.4	38
88.9	95.3	101.6	108.0	114.4	120.7	133.4	139.8	146.1	152.5	158.8	165.2	39
89.4	95.7	102.1	108.5	114.9	121.3	134.0	140.4	146.8	153.2	159.6	165.9	40
89.7	96.2	102.6	109.0	115.4	121.8	134.6	141.0	147.4	153.9	160.3	166.7	41
90.2	96.6	103.0	109.5	115.9	122.4	135.2	141.7	148.1	154.6	161.0	167.4	42
90.6	97.0	103.5	110.0	116.4	122.9	135.8	142.3	148.8	155.2	161.7	168.2	43
91.0	97.5	104.0	110.5	117.0	123.5	136.4	142.9	149.4	155.9	162.4	168.9	44
91.4	97.9	104.4	110.9	117.5	124.0	137.1	143.6	150.1	156.6	163.2	169.7	45
91.8	98.3	104.9	111.4	118.0	124.5	137.7	144.2	150.8	157.3	163.9	170.4	46
92.2	98.8	105.3	111.9	118.5	125.1	138.3	144.8	151.4	158.0	164.6	171.2	47
92.6	99.2	105.8	112.4	119.0	125.6	138.9	145.5	152.1	158.7	165.3	171.9	48
93.0	99.6	106.3	112.9	119.5	126.2	139.5	146.1	152.7	159.4	166.0	172.7	49
93.4	100.1	106.7	113.4	120.1	126.7	140.1	146.8	153.4	160.1	166.8	173.4	50
93.8	100.5	107.2	113.9	120.6	127.3	140.7	147.4	154.1	160.8	167.5	174.2	51
94.2	100.9	107.6	114.4	121.1	127.8	141.3	148.0	154.7	161.5	168.2	174.9	52
94.6	101.4	108.1	114.9	121.6	128.4	141.9	148.6	155.4	162.2	168.9	175.7	53
95.0	101.8	108.6	115.4	122.1	128.9	142.5	149.3	156.1	162.9	169.6	176.4	54
95.4	102.2	109.0	115.8	122.7	129.5	143.1	149.9	156.7	163.5	170.4	177.2	55
95.8	102.6	109.5	116.3	123.2	130.0	143.7	150.6	157.4	164.2	171.1	177.9	56
96.2	103.1	109.9	116.8	123.7	130.6	144.3	151.2	158.1	164.9	171.8	178.7	57
96.6	103.5	110.4	117.3	124.2	131.1	144.9	151.8	158.7	165.6	172.5	179.4	58
97.0	104.0	110.9	117.8	124.7	131.7	145.5	152.5	159.4	166.3	173.3	180.2	59
1395	1494	1594	1694	1793	1893	2092	2192	2291	2391	2491	2590	Hor. Dist.

Hor. dist. is for 30′ point. Add or subtract .035 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

4°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	6.96	13.92	20.87	27.8	34.8	41.8	48.7	55.7	62.6	76.5	83.5	90.5
1	6.99	13.98	20.96	28.0	34.9	41.9	48.9	55.9	62.9	76.9	83.8	90.8
2	7.02	14.03	21.05	28.1	35.1	42.1	49.1	56.1	63.1	77.2	84.2	91.2
3	7.05	14.09	21.14	28.2	35.2	42.3	49.3	56.4	63.4	77.5	84.5	91.6
4	7.08	14.15	21.22	28.3	35.4	42.4	49.5	56.6	63.7	77.8	84.9	92.0
5	7.10	14.21	21.31	28.4	35.5	42.6	49.7	56.8	63.9	78.1	85.2	92.3
6	7.13	14.26	21.39	28.5	35.7	42.8	49.9	57.1	64.2	78.4	85.6	92.7
7	7.16	14.32	21.48	28.6	35.8	43.0	50.1	57.3	64.4	78.8	85.9	93.1
8	7.19	14.38	21.57	28.8	35.9	43.1	50.3	57.5	64.7	79.1	86.3	93.5
9	7.22	14.44	21.65	28.9	36.1	43.3	50.5	57.7	65.0	79.4	86.6	93.8
10	7.25	14.49	21.74	29.0	36.2	43.5	50.7	58.0	65.2	79.7	87.0	94.2
11	7.28	14.55	21.83	29.1	36.4	43.7	50.9	58.2	65.5	80.0	87.3	94.6
12	7.30	14.61	21.91	29.2	36.5	43.8	51.1	58.4	65.7	80.3	87.6	95.0
13	7.33	14.67	22.00	29.3	36.7	44.0	51.3	58.7	66.0	80.7	88.0	95.3
14	7.36	14.72	22.08	29.4	36.8	44.2	51.5	58.9	66.3	81.0	88.3	95.7
15	7.39	14.78	22.17	29.6	37.0	44.3	51.7	59.1	66.5	81.3	88.7	96.1
16	7.42	14.84	22.26	29.7	37.1	44.5	51.9	59.4	66.8	81.6	89.0	96.4
17	7.45	14.90	22.34	29.8	37.2	44.7	52.1	59.6	67.0	81.9	89.4	96.8
18	7.48	14.95	22.43	29.9	37.4	44.9	52.3	59.8	67.3	82.2	89.7	97.2
19	7.51	15.01	22.52	30.0	37.5	45.0	52.5	60.0	67.5	82.6	90.1	97.6
20	7.53	15.07	22.60	30.1	37.7	45.2	52.7	60.3	67.8	82.9	90.4	97.9
21	7.56	15.13	22.69	30.3	37.8	45.4	52.9	60.5	68.1	83.2	90.8	98.3
22	7.59	15.18	22.78	30.4	38.0	45.6	53.1	60.7	68.3	83.5	91.1	98.7
23	7.62	15.24	22.86	30.5	38.1	45.7	53.3	61.0	68.6	83.8	91.4	99.1
24	7.65	15.30	22.95	30.6	38.2	45.9	53.5	61.2	68.8	84.1	91.8	99.4
25	7.68	15.36	23.03	30.7	38.4	46.1	53.7	61.4	69.1	84.5	92.1	99.8
26	7.71	15.41	23.12	30.8	38.5	46.2	53.9	61.7	69.4	84.8	92.5	100.2
27	7.74	15.47	23.21	30.9	38.7	46.4	54.1	61.9	69.6	85.1	92.8	100.6
28	7.76	15.53	23.29	31.1	38.8	46.6	54.4	62.1	69.9	85.4	93.2	100.9
29	7.79	15.59	23.38	31.2	39.0	46.8	54.6	62.3	70.1	85.7	93.5	101.3
30	7.82	15.64	23.46	31.3	39.1	46.9	54.8	62.6	70.4	86.0	93.9	101.7
31	7.85	15.70	23.55	31.4	39.3	47.1	55.0	62.8	70.7	86.4	94.2	102.1
32	7.88	15.76	23.64	31.5	39.4	47.3	55.2	63.0	70.9	86.7	94.5	102.4
33	7.91	15.82	23.72	31.6	39.5	47.4	55.4	63.3	71.2	87.0	94.9	102.8
34	7.94	15.87	23.81	31.7	39.7	47.6	55.6	63.5	71.4	87.3	95.2	103.2
35	7.97	15.93	23.90	31.9	39.8	47.8	55.8	63.7	71.7	87.6	95.6	103.6
36	7.99	15.99	23.98	32.0	40.0	48.0	56.0	64.0	71.9	87.9	95.9	103.9
37	8.02	16.05	24.07	32.1	40.1	48.1	56.2	64.2	72.2	88.2	96.3	104.3
38	8.05	16.10	24.15	32.2	40.3	48.3	56.4	64.4	72.5	88.6	96.6	104.7
39	8.08	16.16	24.24	32.3	40.4	48.5	56.6	64.6	72.7	88.9	97.0	105.0
40	8.11	16.22	24.33	32.4	40.5	48.7	56.8	64.9	73.0	89.2	97.3	105.4
41	8.14	16.27	24.41	32.6	40.7	48.8	57.0	65.1	73.2	89.5	97.7	105.8
42	8.17	16.33	24.50	32.7	40.8	49.0	57.2	65.3	73.5	89.8	98.0	106.2
43	8.20	16.39	24.58	32.8	41.0	49.2	57.4	65.6	73.8	90.1	98.3	106.5
44	8.22	16.45	24.67	32.9	41.1	49.3	57.6	65.8	74.0	90.5	98.7	106.9
45	8.25	16.50	24.76	33.0	41.3	49.5	57.8	66.0	74.3	90.8	99.0	107.3
46	8.28	16.56	24.84	33.1	41.4	49.7	58.0	66.2	74.5	91.1	99.4	107.7
47	8.31	16.62	24.93	33.2	41.6	49.9	58.2	66.5	74.8	91.4	99.7	108.0
48	8.34	16.68	25.02	33.4	41.7	50.0	58.4	66.7	75.0	91.7	100.1	108.4
49	8.37	16.73	25.10	33.5	41.8	50.2	58.6	66.9	75.3	92.0	100.4	108.8
50	8.40	16.79	25.19	33.6	42.0	50.4	58.8	67.2	75.6	92.4	100.8	109.1
51	8.43	16.85	25.27	33.7	42.1	50.5	59.0	67.4	75.8	92.7	101.1	109.5
52	8.45	16.91	25.36	33.8	42.3	50.7	59.2	67.6	76.1	93.0	101.4	109.9
53	8.48	16.96	25.45	33.9	42.4	50.9	59.4	67.9	76.3	93.3	101.8	110.3
54	8.51	17.02	25.53	34.0	42.6	51.1	59.6	68.1	76.6	93.6	102.1	110.6
55	8.54	17.08	25.62	34.2	42.7	51.2	59.8	68.3	76.9	94.9	102.5	111.0
56	8.57	17.14	25.70	34.3	42.8	51.4	60.0	68.5	77.1	94.2	102.8	111.4
57	8.60	17.19	25.79	34.4	43.0	51.6	60.2	68.8	77.4	94.6	103.2	111.8
58	8.63	17.26	25.87	34.5	43.1	51.8	60.4	69.0	77.6	94.9	103.5	112.1
59	8.65	17.31	25.96	34.6	43.3	51.9	60.6	69.2	77.9	95.2	103.8	112.5
Horz. Dist.	99.38	198.8	298.1	397.5	496.9	596	696	795	894	1093	1193	1292

Hor. dist. is for 30′ point. Add or subtract .045 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

4°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
97.4	104.4	111.3	118.3	125.2	132.2	146.1	153.1	160.0	167.0	174.0	180.9	0
97.8	104.8	111.8	118.8	125.8	132.8	146.7	153.7	160.7	167.7	174.7	181.7	1
98.2	105.2	112.3	119.3	126.3	133.3	147.3	154.4	161.4	168.4	175.4	182.4	2
98.6	105.7	112.7	119.8	126.8	133.9	147.9	155.0	162.0	169.1	176.1	183.2	3
99.0	106.1	113.2	120.3	127.3	134.4	148.6	155.6	162.7	169.8	176.8	183.9	4
99.4	106.5	113.6	120.7	127.8	134.9	149.2	156.3	163.4	170.5	177.6	184.7	5
99.8	107.0	114.1	121.2	128.4	135.5	149.8	156.9	164.0	171.2	178.3	185.4	6
100.2	107.4	114.6	121.7	128.9	136.0	150.4	157.5	164.7	171.8	179.0	186.2	7
100.6	107.8	115.0	122.2	129.4	136.6	151.0	158.2	165.3	172.5	179.7	186.9	8
101.0	108.3	115.5	122.7	129.9	137.1	151.6	158.8	166.0	173.2	180.4	187.7	9
101.5	108.7	115.9	123.2	130.4	137.7	152.2	159.4	166.7	173.9	181.2	188.4	10
101.9	109.1	116.4	123.7	131.0	138.2	152.8	160.1	167.3	174.6	181.9	189.2	11
102.3	109.6	116.9	124.2	131.5	138.8	153.4	160.7	168.0	175.3	182.6	189.9	12
102.7	110.0	117.3	124.7	132.0	139.3	154.0	161.3	168.7	176.0	183.3	190.7	13
103.1	110.4	117.8	125.1	132.5	139.9	154.6	162.0	169.3	176.7	184.0	191.4	14
103.5	110.9	118.2	125.6	133.0	140.4	155.2	162.6	170.0	177.4	184.7	192.2	15
103.9	111.3	118.7	126.1	133.5	141.0	155.8	163.2	170.6	178.1	185.5	192.9	16
104.3	111.7	119.2	126.6	134.1	141.5	156.4	163.9	171.3	178.8	186.2	193.6	17
104.7	112.2	119.6	127.1	134.6	142.1	157.0	164.5	172.9	179.4	186.9	194.4	18
105.1	112.6	120.1	127.6	135.1	142.6	157.6	165.1	172.6	180.1	187.6	195.1	19
105.5	113.0	120.6	128.1	135.6	143.2	158.2	165.8	173.3	180.8	188.4	195.9	20
105.9	113.4	121.0	128.6	136.1	143.7	158.8	166.4	173.9	181.5	189.1	196.6	21
106.3	113.9	121.5	129.1	136.7	144.2	159.4	167.0	174.6	182.2	189.8	197.4	22
106.7	114.3	121.9	129.5	137.2	144.8	160.0	167.6	175.3	182.9	190.5	198.1	23
107.1	114.7	122.4	130.0	137.7	145.3	160.6	168.3	175.9	183.6	191.2	198.9	24
107.5	115.2	122.8	130.5	138.2	145.9	161.2	168.9	176.6	184.3	192.0	199.6	25
107.9	115.6	123.3	131.0	138.7	146.4	161.8	169.6	177.3	185.0	192.7	200.4	26
108.3	116.0	123.8	131.5	139.2	147.0	162.4	170.2	177.9	185.7	193.4	201.1	27
108.7	116.5	124.2	132.0	139.8	147.5	163.1	170.8	178.6	186.3	194.1	201.9	28
109.1	116.9	124.7	132.5	140.3	148.1	163.7	171.4	179.2	187.0	194.8	202.6	29
109.5	117.3	125.1	133.0	140.8	148.6	164.3	172.1	189.9	187.7	195.5	203.4	30
109.9	117.8	125.6	133.5	141.3	149.2	164.9	172.7	180.6	188.4	196.3	204.1	31
110.3	118.2	126.1	133.9	141.8	149.7	165.5	173.3	181.2	189.1	197.0	204.9	32
110.7	118.6	126.5	134.4	142.3	150.3	166.1	174.0	181.9	189.8	197.7	205.6	33
111.1	119.0	127.0	134.9	142.9	150.8	166.7	174.6	182.5	190.5	198.4	206.3	34
111.5	119.5	127.4	135.4	143.4	151.3	167.3	175.2	183.2	191.2	199.1	207.1	35
111.9	119.9	127.9	135.9	143.9	151.9	167.9	175.9	183.9	191.9	199.8	207.8	36
112.3	120.3	128.4	136.4	144.4	152.4	168.5	176.5	184.5	192.6	200.6	208.6	37
112.7	120.8	128.8	136.9	144.9	153.0	169.1	177.1	185.2	193.2	201.3	209.3	38
113.1	121.2	129.3	137.4	145.4	153.5	169.7	177.8	185.8	193.9	202.0	210.1	39
113.5	121.6	129.7	137.9	146.9	154.1	170.3	178.4	186.5	194.6	202.7	210.8	40
113.9	122.1	130.2	138.3	146.5	154.6	170.9	179.0	187.2	195.3	203.4	211.6	41
114.3	122.5	130.7	138.8	147.0	155.2	171.5	179.7	187.8	196.0	204.2	212.3	42
114.7	122.9	131.1	139.3	147.5	155.7	172.1	180.3	188.5	196.7	204.9	213.1	43
115.1	123.4	131.6	139.8	148.0	156.2	172.7	180.9	189.1	197.4	205.6	213.8	44
115.5	123.8	132.0	140.3	148.5	156.8	173.3	181.6	189.8	198.1	206.3	214.6	45
115.9	124.2	132.5	140.8	149.1	157.3	173.9	182.2	190.5	198.7	207.0	215.3	46
116.3	124.7	133.9	141.3	149.6	157.9	174.5	182.8	191.1	199.4	207.8	216.1	47
116.7	125.1	133.4	141.8	150.1	158.4	175.1	183.4	191.8	200.1	208.5	216.8	48
117.1	125.5	133.9	142.2	150.6	159.0	175.7	184.1	192.4	200.8	209.2	217.5	49
117.5	125.9	134.3	142.7	151.1	159.5	176.3	184.7	193.1	201.5	209.9	218.3	50
117.9	126.4	134.8	143.2	151.6	160.1	176.9	185.3	193.8	202.2	210.6	219.0	51
118.3	126.8	135.2	143.7	152.2	160.6	177.5	186.0	194.4	202.9	211.3	219.8	52
118.7	127.2	135.7	144.2	152.7	161.2	178.1	186.6	195.1	203.6	212.0	220.5	5.
119.1	127.7	136.2	144.7	153.2	161.7	178.7	187.2	195.7	204.2	212.8	221.3	54
119.5	128.1	136.6	145.2	153.7	162.2	179.3	187.9	196.4	204.9	213.5	222.0	55
120.0	128.5	137.1	145.7	154.2	162.8	179.9	188.5	197.1	205.6	214.2	222.8	56
120.4	128.9	137.5	146.1	154.7	163.3	180.5	189.1	197.7	206.3	214.9	223.5	57
120.8	129.4	138.0	146.6	155.2	163.9	181.1	189.8	198.4	207.0	215.6	224.3	58
121.2	129.8	138.5	147.1	155.8	164.4	181.7	190.4	199.0	207.7	216.4	225.0	59
1391	1491	1590	1689	1789	1888	2087	2186	2286	2385	2484	2584	Hor. Dist.

Hor. dist. is for 30′ point. Add or subtract .048 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES N ELEVATION

5

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	8.68	17.36	26.05	34.7	43.4	52.1	60.8	69.5	78.1	95.5	104.2	112.9
1	8.71	17.42	26.13	34.8	43.6	52.3	61.0	69.7	78.4	95.8	104.5	113.2
2	8.74	17.48	26.22	35.0	43.7	52.4	61.2	69.9	78.7	96.1	104.9	113.6
3	8.77	17.54	26.31	35.1	43.8	52.6	61.4	70.1	78.9	96.4	105.2	114.0
4	8.80	17.59	26.39	35.2	44.0	52.8	61.6	70.4	79.2	96.8	105.6	114.4
5	8.82	17.65	26.48	35.3	44.1	53.0	61.8	70.6	79.4	97.1	105.9	114.7
6	8.85	17.71	26.56	35.4	44.3	53.1	62.0	70.8	79.7	97.4	106.2	115.1
7	8.88	17.77	26.65	35.5	44.4	53.3	62.2	71.1	79.9	97.7	106.6	115.5
8	8.91	17.82	26.73	35.6	44.5	53.5	62.4	71.3	80.2	98.0	106.9	115.8
9	8.94	17.88	26.82	35.8	44.7	53.6	62.6	71.5	80.5	98.3	107.3	116.2
10	8.97	17.94	26.90	35.9	44.8	53.8	62.8	71.8	80.7	98.7	107.6	116.6
11	9.00	18.00	26.99	36.0	44.9	54.0	63.0	72.0	81.0	99.0	108.0	117.0
12	9.03	18.05	27.08	36.1	45.1	54.2	63.2	72.2	81.2	99.3	108.3	117.3
13	9.06	18.11	27.16	36.2	45.3	54.3	63.4	72.4	81.5	99.6	108.7	117.7
14	9.08	18.17	27.25	36.3	45.4	54.5	63.6	72.7	81.7	99.9	109.0	118.1
15	9.11	18.22	27.33	36.4	45.6	54.7	63.8	72.9	82.0	100.2	109.3	118.5
16	9.14	18.28	27.42	36.6	45.7	54.8	64.0	73.1	82.3	100.5	109.7	118.8
17	9.17	18.34	27.51	36.7	45.8	55.0	64.2	73.4	82.5	100.9	110.0	119.2
18	9.20	18.39	27.59	36.8	46.0	55.2	64.4	73.6	82.8	101.1	110.4	119.6
19	9.23	18.45	27.68	36.9	46.1	55.3	64.6	73.8	83.0	101.5	110.7	119.9
20	9.25	18.51	27.76	37.0	46.3	55.5	64.8	74.0	83.3	101.8	111.0	120.3
21	9.28	18.57	27.85	37.1	46.4	55.7	65.0	74.3	83.6	102.1	111.4	120.7
22	9.31	18.62	27.94	37.2	46.6	55.9	65.2	74.5	83.8	102.4	111.7	121.1
23	9.34	18.68	28.02	37.4	46.7	56.0	65.4	74.7	84.1	102.7	112.1	121.4
24	9.37	18.74	28.11	37.5	46.8	56.2	65.6	75.0	84.3	103.1	112.4	121.8
25	9.40	18.80	28.19	37.6	47.0	56.4	65.8	75.2	84.6	103.4	112.8	122.2
26	9.43	18.85	28.28	37.7	47.1	56.5	66.0	75.4	84.8	103.7	113.1	122.5
27	9.46	18.91	28.37	37.8	47.3	56.7	66.2	75.6	85.1	104.0	113.5	122.9
28	9.48	18.97	28.45	37.9	47.4	56.9	66.4	75.9	85.4	104.3	113.8	123.3
29	9.51	19.02	28.54	38.0	47.6	57.1	66.6	76.1	85.6	104.6	114.1	123.7
30	9.54	19.08	28.62	38.2	47.7	57.2	66.8	76.3	85.9	104.9	114.5	124.0
31	9.57	19.14	28.71	38.3	47.8	57.4	67.0	76.6	86.1	105.3	114.8	124.4
32	9.60	19.20	28.79	38.4	48.0	57.6	67.2	76.8	86.4	105.6	115.2	124.8
33	9.63	19.25	28.88	38.5	48.1	57.8	67.4	77.0	86.6	105.9	115.5	125.1
34	9.65	19.31	28.96	38.6	48.3	57.9	67.6	77.2	86.9	106.2	115.9	125.5
35	9.68	19.37	29.05	38.7	48.4	58.1	67.8	77.5	87.2	106.5	116.2	125.9
36	9.71	19.42	29.13	38.8	48.6	58.3	68.0	77.7	87.4	106.8	116.5	126.2
37	9.74	19.48	29.22	39.0	48.7	58.5	68.2	77.9	87.7	107.1	116.9	126.6
38	9.77	19.54	29.31	39.1	48.9	58.6	68.4	78.2	87.9	107.5	117.2	127.0
39	9.80	19.60	29.39	39.2	49.0	58.8	68.6	78.4	88.2	107.8	117.6	127.4
40	9.83	19.65	29.48	39.3	49.2	59.0	68.8	78.6	88.5	108.1	118.0	127.7
41	9.86	19.71	29.56	39.4	49.3	59.2	69.0	78.8	88.7	108.4	118.3	128.1
42	9.88	19.77	29.65	39.5	49.4	59.3	69.2	79.1	89.0	108.7	118.6	128.5
43	9.91	19.81	29.73	39.7	49.6	59.5	69.4	79.3	89.2	109.0	118.9	128.8
44	9.94	19.88	29.82	39.8	49.7	59.6	69.6	79.5	89.5	109.3	119.3	129.2
45	9.97	19.94	29.90	39.9	49.8	59.8	69.8	79.8	89.7	109.7	119.6	129.6
46	10.00	19.99	29.99	40.0	50.0	60.0	70.0	80.0	90.0	110.0	120.0	130.0
47	10.02	20.05	30.08	40.1	50.1	60.2	70.2	80.2	90.2	110.3	120.3	130.3
48	10.05	20.11	30.16	40.2	50.3	60.3	70.4	80.4	90.5	110.6	120.6	130.7
49	10.08	20.16	30.25	40.3	50.4	60.5	70.6	80.7	90.8	110.9	121.0	131.1
50	10.11	20.22	30.33	40.4	50.6	60.7	70.8	80.9	91.0	111.2	121.3	131.4
51	10.14	20.28	30.42	40.6	50.7	60.8	71.0	81.1	91.3	111.5	121.7	131.8
52	10.17	20.34	30.50	40.7	50.8	61.0	71.2	81.3	91.5	111.9	122.0	132.2
53	10.20	20.40	30.59	40.8	51.0	61.2	71.4	81.6	91.8	112.2	122.4	132.6
54	10.22	20.45	30.68	40.9	51.1	61.4	71.6	81.8	92.0	112.5	122.7	132.9
55	10.25	20.51	30.76	41.0	51.3	61.5	71.8	82.0	92.3	112.8	123.0	133.3
56	10.28	20.57	30.84	41.1	51.4	61.7	72.0	82.2	92.5	113.1	123.4	133.6
57	10.31	20.63	30.93	41.2	51.6	61.9	72.2	82.5	92.8	113.4	123.7	134.0
58	10.34	20.68	31.02	41.4	51.7	62.0	72.4	82.7	93.0	113.7	124.1	134.4
59	10.37	20.74	31.10	41.5	51.8	62.2	72.6	82.9	93.3	114.0	124.4	134.8
Horz Dist.	99.08	198.2	297.2	396.3	495.4	594	694	793	892	1090	1189	1288

Hor. dist. is for 30′ point. Add or subtract .055 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

5°

1400	1500	1600	1700	1800	1900	2100	2200	2300	2400	2500	2600	′
121.6	130.2	138.9	147.6	156.3	165.0	182.3	191.0	200.0	208.4	217.1	225.7	0
122.0	130.7	139.4	148.1	156.8	165.5	182.9	191.6	200.4	209.1	217.8	226.5	1
122.4	131.1	139.8	148.6	157.3	166.0	183.5	192.3	201.0	209.7	218.5	227.2	2
122.8	131.5	140.3	149.1	157.8	166.6	184.1	192.9	201.7	210.5	219.2	228.0	3
123.2	132.0	140.8	149.5	158.3	167.1	184.7	193.5	202.3	211.1	219.9	228.7	4
123.6	132.4	141.2	150.0	158.8	167.7	185.3	194.2	203.0	211.8	220.6	229.5	5
124.0	132.8	141.7	150.5	159.4	168.2	185.9	194.8	203.6	212.5	221.4	230.2	6
124.4	133.2	142.1	151.0	159.9	168.8	186.5	195.4	204.3	213.2	222.1	231.0	7
124.8	133.7	142.6	151.5	160.4	169.3	187.1	196.0	205.0	213.9	222.8	231.7	8
125.2	134.1	143.0	152.0	160.9	169.9	187.7	196.7	205.6	214.6	223.5	232.4	9
125.6	134.5	143.5	152.5	161.4	170.4	188.3	197.3	206.3	215.2	224.2	233.2	10
126.0	135.0	144.0	153.0	162.0	171.0	188.9	197.9	206.9	215.9	224.9	233.9	11
126.4	135.4	144.4	153.4	162.5	171.5	189.5	198.6	207.6	216.6	225.6	234.7	12
126.8	135.8	144.9	153.9	163.0	172.0	190.1	199.2	208.3	217.3	226.4	235.4	13
127.2	136.2	145.3	154.4	163.5	172.6	190.7	199.8	208.9	218.0	227.1	236.2	14
127.6	136.7	145.8	154.9	164.0	173.1	191.4	200.5	209.6	218.7	227.8	236.9	15
127.9	137.1	146.2	155.4	164.5	173.7	192.0	201.1	210.2	219.4	228.5	237.7	16
128.4	137.5	146.7	155.9	165.0	174.2	192.5	201.7	210.9	220.1	229.2	238.4	17
128.8	138.0	147.2	156.4	165.6	174.8	193.1	202.3	211.5	220.7	229.9	239.1	18
129.2	138.4	147.6	156.8	166.1	175.3	193.7	203.0	212.2	221.4	230.7	239.9	19
129.6	138.8	148.1	157.3	166.6	175.8	194.3	203.6	212.8	222.1	231.4	240.6	20
130.0	139.3	148.5	157.8	167.1	176.4	195.0	204.2	213.5	222.8	232.1	241.4	21
130.4	139.7	149.0	158.3	167.6	176.9	195.6	204.9	214.2	223.5	232.8	242.1	22
130.8	140.1	149.4	158.8	168.1	177.5	196.2	205.5	214.8	224.2	233.5	242.9	23
131.2	140.5	159.9	159.3	168.6	178.0	196.7	206.1	215.5	224.9	234.2	243.6	24
131.6	141.0	150.4	159.8	169.2	178.6	197.3	206.7	216.1	225.5	234.9	244.3	25
132.0	141.4	150.9	160.2	169.7	179.1	197.9	207.4	216.8	226.2	235.6	245.1	26
132.4	141.9	151.3	160.7	170.2	179.7	198.6	208.0	217.5	226.9	236.4	245.8	27
132.8	142.3	151.7	161.2	170.7	180.2	199.2	208.6	218.1	227.6	237.1	246.6	28
133.2	142.7	152.2	161.7	171.2	180.7	199.7	209.3	218.8	228.3	237.8	247.3	29
133.6	143.1	152.6	162.3	171.7	181.3	200.3	209.9	219.4	229.0	238.5	248.0	30
134.0	143.6	153.1	162.7	172.2	181.8	200.9	210.5	220.1	229.7	239.2	248.8	31
134.4	144.0	153.6	163.2	172.8	182.4	201.5	211.1	220.7	230.3	239.9	249.5	32
134.8	144.4	154.0	163.6	173.3	182.9	202.1	211.8	221.4	231.0	240.6	250.3	33
135.2	144.8	154.5	164.1	173.8	183.4	202.7	212.4	222.1	231.7	241.4	251.0	34
135.6	145.3	155.0	164.6	174.3	184.0	203.3	213.0	222.7	232.4	242.1	251.8	35
136.0	145.7	155.4	165.1	174.8	184.5	203.9	213.7	223.4	233.1	242.8	252.5	36
136.4	146.1	155.8	165.6	175.3	185.1	204.5	214.3	224.0	233.8	243.5	253.3	37
136.8	146.5	156.3	166.1	175.8	185.6	205.1	214.9	224.7	234.5	244.2	254.0	38
137.2	147.0	156.8	166.6	176.4	186.2	205.7	215.5	225.3	235.1	244.9	254.7	39
137.6	147.4	157.2	167.0	176.9	186.7	206.3	216.2	226.0	235.8	245.6	255.5	40
138.0	147.8	157.7	167.5	177.4	187.2	206.9	216.8	226.7	236.5	246.4	256.2	41
138.4	148.2	158.1	168.0	178.9	187.8	207.5	217.4	227.3	237.2	247.1	257.0	42
138.8	148.7	158.6	168.5	178.4	188.3	208.1	218.0	227.9	237.9	247.8	257.7	43
139.2	149.1	159.0	169.0	178.9	189.9	208.7	218.7	228.6	238.6	248.5	258.4	44
139.6	149.5	159.5	169.5	179.4	189.4	209.3	219.3	229.3	239.2	249.2	259.2	45
140.0	150.0	160.0	169.9	179.9	189.9	209.9	219.9	229.9	239.9	249.9	259.9	46
140.4	150.4	160.4	170.4	180.5	190.5	210.5	220.6	230.6	240.6	250.6	260.7	47
140.8	150.8	160.9	170.9	181.0	191.0	211.2	221.2	231.2	241.3	251.4	261.4	48
141.2	151.2	161.3	171.4	181.5	191.6	211.7	221.8	231.9	242.0	252.1	262.1	49
141.6	151.7	161.8	171.9	182.0	192.0	212.4	222.4	232.6	242.7	252.8	262.9	50
142.0	152.1	162.2	172.4	182.5	192.7	212.9	223.1	233.2	243.3	253.5	263.6	51
142.4	152.5	162.7	172.9	183.0	193.2	213.5	223.7	233.9	244.0	254.2	264.4	52
142.8	152.9	163.1	173.3	183.5	193.7	214.1	224.3	234.5	244.7	254.9	265.1	53
143.2	153.4	163.6	173.8	184.0	194.3	214.7	225.0	235.2	245.4	255.6	265.8	54
143.6	153.8	164.1	174.3	184.6	194.8	215.3	225.6	235.8	246.1	256.3	266.6	55
143.9	154.2	164.5	174.8	185.1	195.4	215.9	226.2	236.5	246.8	257.0	267.3	56
144.3	154.6	165.0	175.3	185.6	195.9	216.5	226.8	237.1	247.4	257.8	268.1	57
144.8	155.1	165.4	175.8	186.1	196.4	217.1	227.4	237.8	248.1	258.5	268.8	58
145.1	155.5	165.9	176.2	186.6	197.0	217.7	228.1	238.4	248.8	259.2	269.5	59
1387	1486	1585	1684	1783	1882	2081	2180	2279	2378	2477	2576	Hor. Dist.

Hor. dist. is for 30′ point. Add or subtract .055 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

6°

′	100	200	300	400	500	600	700	800	900	1100	1200	1300
0	10.40	20.79	31.19	41.6	52.0	62.4	72.8	83.2	93.6	114.4	124.7	135.1
1	10.42	20.85	31.27	41.7	52.1	62.5	73.0	83.4	93.8	114.7	125.1	135.5
2	10.45	20.90	31.36	41.8	52.3	62.7	73.2	83.6	94.1	115.0	125.4	135.9
3	10.48	20.96	31.44	41.9	52.4	62.9	73.4	83.8	94.3	115.3	125.8	136.2
4	10.51	21.02	31.53	42.0	52.5	63.1	73.6	84.1	94.6	115.6	126.1	136.6
5	10.54	21.08	31.61	42.2	52.7	63.2	73.8	84.3	94.8	115.9	126.5	137.0
6	10.57	21.13	31.69	42.3	52.8	63.4	74.0	84.5	95.1	116.2	126.8	137.4
7	10.59	21.19	31.78	42.4	53.0	63.6	74.2	84.8	95.4	116.5	127.1	137.7
8	10.62	21.25	31.87	42.5	53.1	63.7	74.4	85.0	95.6	116.8	127.5	138.1
9	10.65	21.30	31.95	42.6	53.3	63.9	74.6	85.2	95.9	117.2	127.8	138.5
10	10.68	21.36	32.04	42.7	53.4	64.1	74.8	85.4	96.1	117.5	128.2	138.8
11	10.71	21.42	32.12	42.8	53.5	64.3	75.0	85.7	96.4	117.8	128.5	139.2
12	10.74	21.47	32.21	42.9	53.7	64.4	75.2	85.9	96.6	118.1	128.8	139.6
13	10.76	21.53	32.30	43.1	53.8	64.6	75.4	86.1	96.9	118.4	129.2	139.9
14	10.79	21.59	32.38	43.2	54.0	64.8	75.6	86.3	97.1	118.7	129.5	140.3
15	10.82	21.64	32.47	43.3	54.1	64.9	75.8	86.6	97.4	119.0	129.9	140.7
16	10.85	21.70	32.55	43.4	54.2	65.1	76.0	86.8	97.6	119.4	130.2	141.1
17	10.88	21.76	32.64	43.5	54.4	65.3	76.2	87.0	97.9	119.7	130.5	141.4
18	10.91	21.81	32.72	43.6	54.5	65.4	76.3	87.3	98.2	120.0	130.9	141.8
19	10.94	21.87	32.81	43.7	54.7	65.6	76.5	87.5	98.4	120.3	131.2	142.2
20	10.96	21.93	32.89	43.9	54.8	65.8	76.7	87.7	98.7	120.6	131.6	142.5
21	10.99	21.98	32.98	44.0	55.0	66.0	76.9	87.9	98.9	120.9	131.9	142.9
22	11.02	22.04	33.06	44.1	55.1	66.1	77.1	88.2	99.2	121.2	132.2	143.3
23	11.05	22.10	33.15	44.2	55.2	66.3	77.3	88.4	99.4	121.5	132.6	143.6
24	11.08	22.16	33.23	44.3	55.4	66.5	77.5	88.6	99.7	121.8	132.9	144.0
25	11.11	22.21	33.32	44.4	55.5	66.6	77.7	88.8	99.9	122.2	133.3	144.4
26	11.13	22.27	33.40	44.5	55.7	66.8	77.9	89.1	100.2	122.5	133.6	144.7
27	11.16	22.33	33.49	44.6	55.8	67.0	78.1	89.3	100.5	122.8	134.0	145.1
28	11.19	22.38	33.57	44.8	56.0	67.1	78.3	89.5	100.7	123.1	134.3	145.5
29	11.22	22.44	33.66	44.9	56.1	67.3	78.5	89.7	101.0	123.4	134.6	145.8
30	11.25	22.49	33.74	45.0	56.2	67.5	78.7	90.0	101.2	123.7	135.0	146.2
31	11.28	22.55	33.83	45.1	56.4	67.7	78.9	90.2	101.5	124.0	135.3	146.6
32	11.30	22.61	33.91	45.2	56.5	67.8	79.1	90.4	101.7	124.3	135.6	147.0
33	11.32	22.66	34.00	45.3	56.7	68.0	79.3	90.7	102.0	124.7	136.0	147.3
34	11.36	22.72	34.08	45.4	56.8	68.2	79.5	90.9	102.2	125.0	136.3	147.7
35	11.39	22.78	34.17	45.6	56.9	68.3	79.7	91.1	102.5	125.3	136.7	148.1
36	11.42	22.84	34.25	45.7	57.1	68.5	79.9	91.3	102.8	125.6	137.0	148.4
37	11.45	22.89	34.34	45.8	57.2	68.7	80.1	91.6	103.0	125.9	137.4	148.8
38	11.47	22.95	34.42	45.9	57.4	68.8	80.3	91.8	103.3	126.2	137.7	149.2
39	11.50	23.00	34.51	46.0	57.5	69.0	80.5	92.0	103.5	126.5	138.0	149.5
40	11.53	23.06	34.59	46.1	57.6	69.2	80.7	92.2	103.8	126.8	138.4	149.9
41	11.56	23.12	34.68	46.2	57.8	69.4	80.9	92.5	104.0	127.1	138.7	150.3
42	11.59	23.18	34.76	46.4	57.9	69.5	81.1	92.7	104.3	127.5	139.0	150.6
43	11.62	23.23	34.84	46.5	58.1	69.7	81.3	92.9	104.5	127.8	139.4	151.0
44	11.64	23.29	34.93	46.6	58.2	69.9	81.5	93.2	104.8	128.1	139.7	151.4
45	11.67	23.34	35.02	46.7	58.4	70.0	81.7	93.4	105.0	128.4	140.1	151.7
46	11.70	23.40	35.10	46.8	58.5	70.2	81.9	93.6	105.3	128.7	140.4	152.1
47	11.73	23.46	35.19	46.9	58.6	70.4	82.1	93.8	105.6	129.0	140.7	152.5
40	11.76	23.51	35.27	47.0	58.8	70.5	82.3	94.1	105.8	129.3	141.1	152.8
49	11.79	23.57	35.36	47.1	58.9	70.7	82.5	94.3	106.1	129.6	141.4	153.2
50	11.81	23.63	35.44	47.3	59.1	70.9	82.7	94.5	106.3	129.9	141.8	153.6
51	11.84	23.68	35.53	47.4	59.2	71.0	82.9	94.7	106.6	130.3	142.1	153.9
52	11.87	23.74	35.61	47.5	59.4	71.2	83.1	95.0	106.8	130.6	142.4	154.3
53	11.90	23.80	35.70	47.6	59.5	71.4	83.3	95.2	107.1	130.9	142.8	154.7
54	11.93	23.85	35.78	47.7	59.6	71.6	83.5	95.4	107.3	131.2	143.1	155.0
55	11.96	23.91	35.86	47.8	59.8	71.7	83.7	95.6	107.6	131.5	143.5	155.4
56	11.98	23.97	35.95	47.9	59.9	71.9	83.9	95.9	107.8	131.8	143.8	155.8
57	12.01	24.02	36.03	48.0	60.1	72.1	84.1	96.1	108.1	132.1	144.1	156.1
58	12.04	24.08	36.12	48.2	60.2	72.2	84.3	96.3	108.4	132.4	144.5	156.5
59	12.07	24.14	36.20	48.3	60.3	72.4	84.5	96.5	108.7	132.7	144.8	156.9
Horz. Dist.	98.72	197.4	296.2	394.9	493.6	592	691	790	888	1086	1185	1283

Hor. dist. is for 30′ point. Add or subtract .065 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

7°

100	200	300	400	500	600	700	800	900	1100	1200	1300	′
12.10	24.19	36.29	48.4	60.5	72.6	84.7	96.8	108.9	133.1	145.2	157.2	0
12.12	24.25	36.37	48.5	60.6	72.7	84.9	97.0	109.1	133.4	145.5	157.6	1
12.15	24.30	36.46	48.6	60.8	72.9	85.1	97.2	109.4	133.7	145.8	158.0	2
12.18	24.36	36.54	48.7	60.9	73.1	85.3	97.4	109.6	134.0	146.2	158.4	3
12.21	24.42	36.63	48.8	61.1	73.2	85.5	97.7	109.9	134.3	146.5	158.7	4
12.24	24.47	36.71	48.9	61.2	73.4	85.7	97.9	110.1	134.6	146.8	159.1	5
12.27	24.53	36.80	49.1	61.3	73.6	85.9	98.1	110.4	134.9	147.2	159.4	6
12.29	24.59	36.88	49.2	61.5	73.8	86.0	98.3	110.6	135.2	147.5	159.8	7
12.32	24.64	36.97	49.3	61.6	73.9	86.2	98.6	110.9	135.5	147.9	160.2	8
12.35	24.70	37.05	49.4	61.8	74.1	86.4	98.8	111.2	135.8	148.2	160.6	9
12.38	24.76	37.13	49.5	61.9	74.3	86.6	99.0	111.4	136.2	148.6	160.9	10
12.41	24.81	37.22	49.6	62.0	74.4	86.8	99.2	111.7	136.5	148.9	161.3	11
12.43	24.87	37.30	49.7	62.2	74.6	87.0	99.5	111.9	136.8	149.2	161.6	12
12.46	24.92	37.39	49.8	62.3	74.8	87.2	99.7	112.2	137.1	149.6	162.0	13
12.49	24.98	37.47	50.0	62.5	74.9	87.4	99.9	112.4	137.4	149.9	162.4	14
12.52	25.04	37.56	50.1	62.6	75.1	87.6	100.2	112.7	137.7	150.2	162.7	15
12.55	25.09	37.64	50.2	62.7	75.3	87.8	100.4	112.9	138.0	150.6	163.1	16
12.58	25.15	37.73	50.3	62.9	75.4	88.0	100.6	113.2	138.3	150.9	163.5	17
12.60	25.21	37.81	50.4	63.0	75.6	88.2	100.8	113.4	138.6	151.2	163.8	18
12.63	25.26	37.89	50.5	63.2	75.8	88.4	101.0	113.7	138.9	151.6	164.2	19
12.66	25.32	37.98	50.6	63.3	76.0	88.6	101.3	113.9	139.3	151.9	164.6	20
12.69	25.38	38.06	50.8	63.4	76.1	88.8	101.5	114.2	139.6	152.3	164.9	21
12.72	25.43	38.15	50.9	63.6	76.3	89.0	101.7	114.4	139.9	152.6	165.3	22
12.74	25.49	38.23	51.0	63.7	76.5	89.2	102.0	114.7	140.2	152.9	165.7	23
12.77	25.54	38.32	51.1	63.9	76.6	89.4	102.2	115.0	140.5	153.3	166.0	24
12.80	25.60	38.40	51.2	64.0	76.8	89.6	102.4	115.2	140.8	153.6	166.4	25
12.83	25.66	38.49	51.3	64.1	77.0	90.0	102.6	115.5	141.1	153.9	166.8	26
12.86	25.71	38.57	51.4	64.3	77.1	90.0	102.8	115.7	141.4	154.3	167.1	27
12.88	25.77	38.65	51.5	64.4	77.3	90.2	103.1	116.0	141.7	154.6	167.4	28
12.91	25.83	38.74	51.6	64.6	77.5	90.4	103.3	116.2	142.0	155.0	167.9	29
12.94	25.88	38.82	51.8	64.7	77.6	90.6	103.5	116.5	142.4	155.3	168.2	30
12.97	25.94	38.91	51.9	64.8	77.8	90.8	103.8	116.7	142.7	155.6	168.6	31
13.00	25.99	38.99	52.0	65.0	78.0	91.0	104.0	117.0	143.0	156.0	169.0	32
13.02	26.05	39.08	52.1	65.1	78.1	91.2	104.2	117.2	143.3	156.3	169.3	33
13.05	26.11	39.16	52.2	65.3	78.3	91.4	104.4	117.5	143.6	156.6	169.7	34
13.08	26.16	39.24	52.3	65.4	78.5	91.6	104.6	117.7	143.9	157.0	170.0	35
13.11	26.22	39.33	52.4	65.5	78.7	91.8	104.9	118.0	144.2	157.3	170.4	36
13.14	26.28	39.41	52.6	65.7	78.8	92.0	105.1	118.2	144.5	157.6	170.8	37
13.17	26.33	39.50	52.7	65.8	79.0	92.2	105.3	118.5	144.8	158.0	171.2	38
13.20	26.40	39.60	52.8	66.0	79.2	92.4	105.6	118.8	145.2	158.4	171.6	39
13.22	26.44	39.66	52.9	66.1	79.3	92.6	105.8	119.0	145.4	158.7	171.9	40
13.25	26.50	39.75	53.0	66.2	79.5	92.8	106.0	119.2	145.8	159.0	172.2	41
13.28	26.56	39.83	53.1	66.4	79.7	92.9	106.2	119.5	146.1	159.3	172.6	42
13.31	26.61	39.92	53.2	66.5	79.8	93.1	106.4	119.8	146.4	159.7	173.0	43
13.33	26.67	40.00	53.3	66.7	80.0	93.3	106.7	120.0	146.7	160.0	173.3	44
13.36	26.72	40.09	53.4	66.8	80.2	93.5	106.9	120.3	147.0	160.3	173.7	45
13.39	26.78	40.17	53.6	67.0	80.3	93.7	107.1	120.5	147.2	160.6	174.0	46
13.42	26.84	40.25	53.7	67.1	80.5	93.9	107.3	120.8	147.6	161.0	174.4	47
13.45	26.89	40.34	53.8	67.2	80.7	94.1	107.6	121.0	147.9	161.4	174.8	48
13.47	26.94	40.42	53.9	67.4	80.8	94.3	107.8	121.3	148.2	161.7	175.2	49
13.50	27.00	40.50	54.0	67.5	81.0	94.5	108.0	121.5	148.6	162.0	175.5	50
13.53	27.06	40.59	54.1	67.7	81.2	94.7	108.2	121.8	148.8	162.4	175.9	51
13.56	27.12	40.67	54.2	67.8	81.3	94.9	108.5	122.0	149.1	162.7	176.2	52
13.59	27.17	40.76	54.3	67.9	81.5	95.1	108.7	122.3	149.4	163.0	176.6	53
13.61	27.23	40.84	54.5	68.1	81.7	95.3	108.9	122.5	149.8	163.4	177.0	54
13.64	27.28	40.93	54.6	68.2	81.8	95.5	109.1	122.8	150.1	163.7	177.3	55
13.67	27.34	41.01	54.7	68.4	82.0	95.7	109.4	123.0	150.4	164.0	177.7	56
13.70	27.40	41.09	54.8	68.5	82.2	95.9	109.6	123.3	150.7	164.4	178.1	57
13.73	27.45	41.18	54.9	68.6	82.4	96.1	109.8	123.5	151.0	164.7	178.4	58
13.75	27.51	41.26	55.0	68.8	82.5	96.3	110.0	123.8	151.3	165.0	178.8	59
98.29	196.6	294.9	393.2	491.4	590	688	786	885	1081	1179	1278	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .075 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

8°

′	100	200	300	400	500	600	700	800	900	1100	′
0	13.78	27.56	41.35	55.1	68.9	82.7	96.5	110.3	124.0	151.6	0
1	13.81	27.62	41.43	55.2	69.0	82.9	96.7	110.5	124.3	151.9	1
2	13.84	27.68	41.51	55.4	69.2	83.0	96.9	110.7	124.5	152.2	2
3	13.87	27.73	41.60	55.5	69.3	83.2	97.1	110.9	124.8	152.5	3
4	13.89	27.78	41.68	55.6	69.5	83.4	97.3	111.2	125.0	152.8	4
5	13.92	27.84	41.76	55.7	69.6	83.5	97.4	111.4	125.3	153.1	5
6	13.95	27.90	41.85	55.8	69.8	83.7	97.6	111.6	125.6	153.4	6
7	13.98	27.96	41.93	55.9	69.9	83.9	97.8	111.8	125.8	153.8	7
8	14.01	28.01	42.02	56.0	70.0	84.0	98.0	112.0	126.0	154.1	8
9	14.03	28.07	42.10	56.1	70.2	84.2	98.2	112.3	126.3	154.4	9
10	14.06	28.12	42.18	56.2	70.3	84.4	98.4	112.5	126.6	154.7	10
11	14.09	28.18	42.27	56.4	70.4	84.5	98.6	112.7	126.8	155.0	11
12	14.12	28.23	42.35	56.5	70.6	84.7	98.8	112.9	127.0	155.3	12
13	14.14	28.29	42.44	56.6	70.7	84.9	99.0	113.2	127.3	155.6	13
14	14.17	28.35	42.52	56.7	70.9	85.0	99.2	113.4	127.6	155.9	14
15	14.20	28.40	42.60	56.8	71.0	85.2	99.4	113.6	127.8	156.2	15
16	14.23	28.46	42.68	56.9	71.1	85.4	99.6	113.8	128.0	156.5	16
17	14.26	28.51	42.77	57.0	71.3	85.5	99.8	114.0	128.3	156.8	17
18	14.28	28.57	42.85	57.1	71.4	85.7	100.0	114.3	128.6	157.1	18
19	14.31	28.62	42.94	57.2	71.6	85.9	100.2	114.5	128.8	157.4	19
20	14.34	28.68	43.02	57.4	71.7	86.0	100.4	114.7	129.1	157.7	20
21	14.37	28.74	43.10	57.5	71.8	86.2	100.6	114.9	129.3	158.0	21
22	14.40	28.79	43.19	57.6	72.0	86.4	100.8	115.2	129.6	158.4	22
23	14.42	28.95	43.27	57.7	72.1	86.5	101.0	115.4	129.8	158.7	23
24	14.45	28.90	43.36	57.8	72.3	86.7	101.2	115.6	130.1	159.0	24
25	14.48	29.96	43.44	57.9	72.4	86.9	101.4	115.8	130.3	159.3	25
26	14.51	29.02	43.52	58.0	72.5	87.0	101.6	116.1	130.6	159.6	26
27	14.54	29.07	43.60	58.1	72.7	87.2	101.7	116.3	130.8	159.9	27
28	14.56	29.13	43.69	58.2	72.8	87.4	101.9	116.5	131.1	160.2	28
29	14.59	29.18	43.77	58.4	73.0	87.6	102.1	116.7	131.3	160.5	29
30	14.62	29.24	43.85	58.5	73.1	87.7	102.3	116.9	131.6	160.8	30
31	14.65	29.29	43.94	58.6	73.2	87.9	102.5	117.2	131.8	161.1	31
32	14.67	29.35	44.02	58.7	73.4	88.0	102.7	117.4	132.1	161.4	32
33	14.70	29.40	44.11	58.8	73.5	88.2	102.9	117.6	132.3	161.7	33
34	14.73	29.46	44.19	58.9	73.6	88.4	103.1	117.8	132.6	162.0	34
35	14.76	29.52	44.27	59.0	73.8	88.6	103.3	118.1	132.8	162.3	35
36	14.79	29.57	44.36	59.1	73.9	88.7	103.5	118.3	133.1	162.6	36
37	14.81	29.63	44.44	59.2	74.1	88.9	103.7	118.5	133.3	162.9	37
38	14.84	29.68	44.52	59.4	74.2	89.0	103.9	118.7	133.6	163.2	38
39	14.87	29.74	44.61	59.5	74.3	89.2	104.1	119.0	133.8	163.6	39
40	14.90	29.78	44.69	59.6	74.5	89.4	104.3	119.2	134.1	163.9	40
41	14.92	29.85	44.77	59.7	74.6	89.6	104.5	119.4	134.3	164.2	41
42	14.95	29.90	44.86	59.8	74.8	89.7	104.7	119.6	134.6	164.5	42
43	14.98	29.96	44.94	59.9	74.9	89.9	104.9	119.8	134.8	164.8	43
44	15.01	30.02	45.02	60.0	75.0	90.0	105.0	120.1	135.1	165.1	44
45	15.04	30.07	45.11	60.1	75.2	90.2	105.2	120.3	135.3	165.4	45
46	15.06	30.13	45.18	60.2	75.3	90.4	105.4	120.5	135.6	165.7	46
47	15.09	30.18	45.27	60.4	75.5	90.6	105.6	120.7	135.8	166.0	47
48	15.12	30.24	45.36	60.5	75.6	90.7	105.8	121.0	136.1	166.3	48
49	15.15	30.29	45.44	60.6	75.7	90.9	106.0	121.2	136.3	166.6	49
50	15.17	30.35	45.52	60.7	75.9	91.0	106.2	121.4	136.6	166.9	50
51	15.20	30.40	45.60	60.8	76.0	91.2	106.4	121.6	136.8	167.2	51
52	15.23	30.46	45.69	60.9	76.2	91.4	106.6	121.8	137.1	167.5	52
53	15.26	30.51	45.77	61.0	76.3	91.5	106.8	122.1	137.3	167.8	53
54	15.28	30.57	45.86	61.1	76.4	91.7	107.0	122.3	137.6	168.1	54
55	15.31	30.62	45.94	61.2	76.6	91.9	107.2	122.5	137.8	168.4	55
56	15.34	30.68	46.02	61.4	76.7	92.0	107.4	122.7	138.1	168.7	56
57	15.37	30.74	46.10	61.5	76.8	92.2	107.6	122.9	138.3	169.0	57
58	15.40	30.79	46.19	61.6	77.0	92.4	107.8	123.2	138.6	169.4	58
59	15.42	30.85	46.27	61.7	77.1	92.5	108.0	123.4	138.8	169.6	59
Horz. Dist.	97.82	195.6	293.5	391.3	489.1	587	685	783	880	1076	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .085 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

9°

′	100	200	300	400	500	600	700	800	900	1100	′
0	15.45	30.90	46.35	61.8	77.3	92.7	108.2	123.6	139.1	170.0	0
1	15.48	30.96	46.44	61.9	77.4	92.9	108.4	123.8	139.3	170.3	1
2	15.51	31.01	46.52	62.0	77.5	93.0	108.5	124.0	139.6	170.6	2
3	15.53	31.07	46.60	62.1	77.7	93.2	108.7	124.3	139.8	170.9	3
4	15.56	31.12	46.68	62.2	77.8	93.4	108.9	124.5	140.0	171.2	4
5	15.59	31.18	46.77	62.4	77.9	93.5	109.1	124.7	140.3	171.5	5
6	15.62	31.23	46.85	62.5	78.1	93.7	109.3	124.9	140.6	171.8	6
7	15.64	31.29	46.93	62.6	78.2	93.9	109.5	125.2	140.8	172.1	7
8	15.67	31.34	47.02	62.7	78.4	94.0	109.7	125.4	141.0	172.4	8
9	15.70	31.40	47.10	62.8	78.5	94.2	109.9	125.6	141.3	172.7	9
10	15.73	31.45	47.18	62.9	78.6	94.4	110.1	125.8	141.5	173.0	10
11	15.76	31.51	47.26	63.0	78.8	94.5	110.3	126.0	141.8	173.3	11
12	15.78	31.56	47.35	63.1	78.9	94.7	110.5	126.3	142.0	173.6	12
13	15.81	31.62	47.43	63.2	79.0	94.9	110.7	126.5	142.3	173.9	13
14	15.84	31.68	47.51	63.4	79.2	95.0	110.9	126.7	142.5	174.2	14
15	15.86	31.73	47.60	63.5	79.3	95.2	111.1	126.9	142.8	174.5	15
16	15.89	31.79	47.68	63.6	79.5	95.4	111.2	127.1	143.0	174.8	16
17	15.92	31.84	47.76	63.7	79.6	95.5	111.4	127.4	143.3	175.1	17
18	15.95	31.90	47.84	63.8	79.7	95.7	111.6	127.6	143.5	175.4	18
19	15.98	31.95	47.93	63.9	79.9	95.8	111.8	127.8	143.8	175.7	19
20	16.00	32.01	48.01	64.0	80.0	96.0	112.0	128.0	144.0	176.0	20
21	16.03	32.06	48.09	64.1	80.2	96.2	112.2	128.2	144.3	176.3	21
22	16.06	32.12	48.17	64.2	80.3	96.4	112.4	128.5	144.5	176.6	22
23	16.09	32.17	48.26	64.3	80.4	96.5	112.6	128.7	144.8	176.9	23
24	16.11	32.23	48.34	64.4	80.6	96.7	112.8	128.9	145.0	177.2	24
25	16.14	32.28	48.42	64.6	80.7	96.8	113.0	129.1	145.3	177.6	25
26	16.17	32.34	48.51	64.7	80.8	97.0	113.2	129.4	145.5	177.8	26
27	16.20	32.39	48.59	64.8	81.0	97.2	113.4	129.6	145.8	178.2	27
28	16.22	32.45	48.67	64.9	81.1	97.3	113.6	129.8	146.0	178.5	28
29	16.25	32.50	48.75	65.0	81.3	97.5	113.8	130.0	146.3	178.8	29
30	16.28	32.56	48.84	65.1	81.4	97.7	114.0	130.2	146.5	179.1	30
31	16.31	32.61	48.92	65.2	81.5	97.8	114.1	130.4	146.8	179.4	31
32	16.33	32.67	49.00	65.3	81.7	98.0	114.3	130.7	147.0	179.7	32
33	16.36	32.72	49.08	65.4	81.8	98.2	114.5	130.9	147.2	180.0	33
34	16.39	32.78	49.17	65.6	81.9	98.3	114.7	131.1	147.5	180.3	34
35	16.42	32.83	49.25	65.7	82.1	98.5	114.9	131.3	147.7	180.6	35
36	16.44	32.89	49.33	65.8	82.2	98.7	115.1	131.6	148.0	180.9	36
37	16.47	32.94	49.41	65.9	82.4	98.8	115.3	131.8	148.2	181.2	37
38	16.50	33.00	49.50	66.0	82.5	99.0	115.5	132.0	148.5	181.5	38
39	16.53	33.05	49.58	66.1	82.6	99.2	115.7	132.2	148.7	181.8	39
40	1. 55	33.11	49.66	66.2	82.8	99.3	115.9	132.4	149.0	182.1	40
41	16.58	33.16	49.74	66.3	82.9	99.5	116.1	132.6	149.2	182.4	41
42	16.61	33.22	49.82	66.4	83.0	99.6	116.3	132.9	149.5	182.7	42
43	16.64	33.27	49.91	66.5	83.2	99.8	116.4	133.1	149.7	183.0	43
44	16.66	33.33	50.00	66.6	83.3	100.0	116.6	133.3	150.0	183.3	44
45	16.69	33.38	50.07	66.8	83.4	100.1	116.8	133.5	150.2	183.6	45
46	16.72	33.44	50.15	66.9	83.6	100.3	117.0	133.7	150.5	183.9	46
47	16.74	33.49	50.24	67.0	83.7	100.5	117.2	134.0	150.7	184.2	47
48	16.77	33.54	50.32	67.1	83.9	100.6	117.4	134.2	151.0	184.5	48
49	16.80	33.60	50.40	67.2	84.0	100.8	117.6	134.4	151.2	184.8	49
50	16.83	33.66	50.48	67.3	84.1	101.0	117.8	134.6	151.4	185.1	50
51	16.86	33.71	50.56	67.4	84.3	101.1	118.0	134.8	151.7	185.4	51
52	16.88	33.76	50.65	67.5	84.4	101.3	118.2	135.1	151.9	185.7	52
53	16.91	33.82	50.73	67.6	84.6	101.5	118.4	135.3	152.2	186.0	53
54	16.94	33.87	50.81	67.8	84.7	101.6	118.6	135.5	152.4	186.3	54
55	16.96	33.93	50.89	67.9	84.8	101.8	118.8	135.7	152.7	186.6	55
56	16.99	33.98	50.98	68.0	85.0	102.0	118.9	135.9	152.9	186.9	56
57	17.02	34.04	51.06	68.1	85.1	102.1	119.1	136.2	153.2	187.2	57
58	17.05	34.09	51.14	68.2	85.2	102.3	119.3	136.4	153.4	187.5	58
59	17.08	34.16	51.24	68.3	85.4	102.5	119.5	136.6	153.7	187.9	59
Horz. Dist.	97.28	194.6	291.9	389.2	486.4	584	681	778	876	1070	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .095 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*
DIFFERENCES IN ELEVATION
10°

′	100	200	300	400	500	600	700	800	900	1100	′
0	17.10	34.20	51.30	68.4	85.5	102.6	119.7	136.8	153.9	188.1	0
1	17.13	34.26	51.39	68.5	85.6	102.8	119.9	137.0	154.2	188.4	1
2	17.16	34.31	51.47	68.6	85.8	102.9	120.1	137.2	154.4	188.7	2
3	17.18	34.37	51.55	68.7	85.9	103.1	120.3	137.5	154.6	189.0	3
4	17.21	34.42	51.63	68.8	86.0	103.3	120.5	137.7	154.9	189.3	4
5	17.24	34.48	51.71	69.0	86.2	103.4	120.7	137.9	155.1	189.6	5
6	17.26	34.53	51.80	69.1	86.3	103.6	120.9	138.1	155.4	189.9	6
7	17.29	34.58	51.88	69.2	86.5	103.8	121.0	138.3	155.6	190.2	7
8	17.32	34.64	51.96	69.3	86.6	103.9	121.2	138.6	155.9	190.5	8
9	17.35	34.69	52.04	69.4	86.7	104.1	121.4	138.8	156.1	190.8	9
10	17.37	34.75	52.12	69.5	86.9	104.2	121.6	139.0	156.4	191.1	10
11	17.40	34.80	52.20	69.6	87.0	104.4	121.8	139.2	156.6	191.4	11
12	17.43	34.86	52.29	69.7	87.1	104.6	122.0	139.4	156.9	191.7	12
13	17.46	34.91	52.37	69.8	87.3	104.7	122.2	139.6	157.1	192.0	13
14	17.48	34.97	52.45	69.9	87.4	104.9	122.4	139.9	157.4	192.3	14
15	17.51	35.02	52.53	70.0	87.6	105.1	122.6	140.1	157.6	192.6	15
16	17.54	35.08	52.61	70.2	87.7	105.2	122.8	140.3	157.8	192.9	16
17	17.56	35.13	52.70	70.3	87.8	105.4	123.0	140.5	158.1	193.2	17
18	17.59	35.18	52.78	70.4	88.0	105.6	123.1	140.7	158.3	193.5	18
19	17.62	35.24	52.86	70.5	88.1	105.7	123.3	141.0	158.6	193.8	19
20	17.65	35.29	52.94	70.6	88.2	105.9	123.5	141.2	158.8	194.1	20
21	17.67	35.35	53.02	70.7	88.4	106.0	123.7	141.4	159.1	194.4	21
22	17.70	35.40	53.10	70.8	88.5	106.2	123.9	141.6	159.3	194.7	22
23	17.73	35.46	53.18	70.9	88.6	106.4	124.1	141.8	159.6	195.0	23
24	17.76	35.51	53.27	71.0	88.8	106.5	124.3	142.0	159.8	195.3	24
25	17.78	35.56	53.35	71.1	88.9	106.7	124.5	142.3	160.0	195.6	25
26	17.81	35.62	53.43	71.2	89.0	106.9	124.7	142.5	160.3	195.9	26
27	17.84	35.67	53.51	71.4	89.2	107.0	124.9	142.7	160.5	196.2	27
28	17.86	35.73	53.59	71.5	89.3	107.2	125.0	142.9	160.8	196.5	28
29	17.89	35.78	53.67	71.6	89.5	107.4	125.2	143.1	161.0	196.8	29
30	17.92	35.84	53.76	71.7	89.6	107.5	125.4	143.4	161.3	197.1	30
31	17.95	35.89	53.84	71.8	89.7	107.7	125.6	143.6	161.5	197.4	31
32	17.97	35.94	53.92	71.9	89.9	107.8	125.8	143.8	161.8	197.7	32
33	18.00	36.00	54.00	72.0	90.0	108.0	126.0	144.0	162.0	198.0	33
34	18.03	36.05	54.08	72.1	90.1	108.2	126.2	144.2	162.2	198.3	34
35	18.05	36.11	54.16	72.2	90.3	108.3	126.4	144.4	162.5	198.6	35
36	18.08	36.16	54.24	72.3	90.4	108.5	126.6	144.6	162.7	198.9	36
37	18.11	36.22	54.33	72.4	90.5	108.6	126.8	144.9	163.0	199.2	37
38	18.14	36.27	54.41	72.5	90.7	108.8	127.0	145.1	163.2	199.5	38
39	18.16	36.32	54.49	72.6	90.8	109.0	127.1	145.3	163.5	199.8	39
40	18.19	36.38	54.57	72.8	91.0	109.1	127.3	145.5	163.7	200.1	40
41	18.22	36.43	54.65	72.9	91.1	109.3	127.5	145.7	164.0	200.4	41
42	18.24	36.49	54.73	73.0	91.2	109.5	127.7	146.0	164.2	200.7	42
43	18.27	36.54	54.81	73.1	91.4	109.6	127.9	146.2	164.4	201.0	43
44	18.30	36.60	54.89	73.2	91.5	109.8	128.1	146.4	164.7	201.3	44
45	18.32	36.65	54.98	73.3	91.6	110.0	128.3	146.6	164.9	201.6	45
46	18.35	36.70	55.06	73.4	91.8	110.1	128.5	146.8	165.2	201.9	46
47	18.38	36.76	55.14	73.5	91.9	110.3	128.6	147.0	165.4	202.2	47
48	18.41	36.81	55.22	73.6	92.0	110.4	128.8	147.2	165.6	202.5	48
49	18.43	36.87	55.30	73.7	92.2	110.6	129.0	147.5	165.9	202.8	49
50	18.46	36.92	55.38	73.8	92.3	110.8	129.2	147.7	166.1	203.1	50
51	18.49	36.98	55.46	74.0	92.4	110.9	129.4	147.9	166.4	203.4	51
52	18.51	37.03	55.54	74.1	92.6	111.1	129.6	148.1	166.6	203.7	52
53	18.54	37.08	55.62	74.2	92.7	111.2	129.8	148.3	166.9	204.0	53
54	18.57	37.14	55.71	74.3	92.8	111.4	130.0	148.6	167.1	204.2	54
55	18.60	37.19	55.79	74.4	93.0	111.6	130.2	148.8	167.4	204.6	55
56	18.62	37.24	55.87	74.5	93.1	111.7	130.4	149.0	167.6	204.8	56
57	18.65	37.30	55.95	74.6	93.2	111.9	130.6	149.2	167.8	205.1	57
58	18.68	37.35	56.03	74.7	93.4	112.1	130.7	149.4	168.1	205.4	58
59	18.70	37.41	56.11	74.8	93.5	112.2	130.9	149.6	168.3	205.7	59
Horz. Dist.	96.68	193.4	290.0	386.7	483.4	580	677	773	870	1064	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .105 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

11

′	100	200	300	400	500	600	700	800	900	1100	′
0	18.73	37.46	56.19	74.9	93.6	112.4	131.1	149.8	168.6	206.0	0
1	18.76	37.52	56.27	75.0	93.8	112.6	131.3	150.1	168.8	206.3	1
2	18.78	37.57	56.36	75.1	93.9	112.7	131.5	150.3	169.1	206.6	2
3	18.81	37.62	56.43	75.2	94.1	112.9	131.7	150.5	169.3	206.9	3
4	18.84	37.68	56.51	75.4	94.2	113.0	131.9	150.7	169.5	207.2	4
5	18.86	37.73	56.60	75.5	94.3	113.2	132.1	150.9	169.8	207.5	5
6	18.89	37.78	56.68	75.6	94.5	113.4	132.2	151.1	170.0	207.8	6
7	18.92	37.84	56.76	75.7	94.6	113.5	132.4	151.4	170.3	208.1	7
8	18.95	37.89	56.84	75.8	94.7	113.7	132.6	151.6	170.5	208.4	8
9	18.97	37.95	56.92	75.9	94.9	113.8	132.8	151.8	170.8	208.7	9
10	19.00	38.00	57.00	76.0	95.0	114.0	133.0	152.0	171.0	209.0	10
11	19.03	38.05	57.08	76.1	95.1	114.2	133.2	152.2	171.2	209.3	11
12	19.05	38.11	57.16	76.2	95.3	114.3	133.4	152.4	171.5	209.6	12
13	19.08	38.16	57.24	76.3	95.4	114.5	133.6	152.6	171.7	209.9	13
14	19.11	38.22	57.32	76.4	95.5	114.6	133.8	152.9	172.0	210.2	14
15	19.13	38.27	57.40	76.5	95.7	114.8	133.9	153.1	172.2	210.5	15
16	19.16	38.32	57.48	76.6	95.8	115.0	134.1	153.3	172.4	210.8	16
17	19.19	38.38	57.56	76.8	95.9	115.1	134.3	153.5	172.7	211.1	17
18	19.22	38.43	57.64	76.9	96.1	115.3	134.5	153.7	172.9	211.4	18
19	19.24	38.48	57.72	77.0	96.2	115.4	134.7	153.9	173.2	211.7	19
20	19.27	38.54	57.81	77.1	96.3	115.6	134.9	154.2	173.4	212.0	20
21	19.30	38.59	57.89	77.2	96.5	115.8	135.1	154.4	173.7	212.2	21
22	19.32	38.64	57.97	77.3	96.6	115.9	135.2	154.6	173.9	212.5	22
23	19.35	38.70	58.05	77.4	96.8	116.1	135.4	154.8	174.1	212.8	23
24	19.38	38.75	58.13	77.5	96.9	116.3	135.6	155.0	174.4	213.1	24
25	19.40	38.80	58.21	77.6	97.0	116.4	135.8	155.2	174.6	213.4	25
26	19.43	38.86	58.29	77.7	97.2	116.6	136.0	155.4	174.9	213.7	26
27	19.46	38.91	58.37	77.8	97.3	116.7	136.2	155.6	175.1	214.0	27
28	19.48	38.97	58.45	77.9	97.4	116.9	136.4	155.9	175.4	214.3	28
29	19.51	39.02	58.53	78.0	97.6	117.1	136.6	156.1	175.6	214.6	29
30	19.54	39.07	58.61	78.2	97.7	117.2	136.8	156.3	175.8	214.9	30
31	19.56	39.13	58.69	78.2	97.8	117.4	136.9	156.5	176.1	215.2	31
32	19.59	39.18	58.77	78.4	98.0	117.5	137.1	156.7	176.3	215.5	32
33	19.62	39.23	58.85	78.5	98.1	117.7	137.3	156.9	176.6	215.8	33
34	19.64	39.29	58.93	78.6	98.2	117.9	137.5	157.2	176.8	216.1	34
35	19.67	39.34	59.01	78.7	98.4	118.0	137.7	157.4	177.0	216.4	35
36	19.70	39.39	59.09	78.8	98.5	118.2	137.9	157.6	177.3	216.7	36
37	19.72	39.45	59.17	78.9	98.6	118.3	138.1	157.8	177.5	217.0	37
38	19.75	39.50	59.25	79.0	98.8	118.5	138.2	158.0	177.8	217.3	38
39	19.78	39.56	59.33	79.1	98.9	118.7	138.4	158.2	178.0	217.6	39
40	19.80	39.61	59.41	79.2	99.0	118.8	138.6	158.4	178.2	217.8	40
41	19.83	39.66	59.49	79.3	99.2	119.0	138.8	158.6	178.5	218.1	41
42	19.86	39.72	59.57	79.4	99.3	119.2	139.0	158.9	178.7	218.4	42
43	19.88	39.77	59.65	79.5	99.4	119.3	139.2	159.1	179.0	218.7	43
44	19.91	39.82	59.73	79.6	99.6	119.5	139.4	159.3	179.2	219.0	44
45	19.94	39.88	59.81	79.8	99.7	119.6	139.6	159.5	179.4	219.3	45
46	19.96	39.93	59.89	79.9	99.8	119.8	139.8	159.7	179.7	219.6	46
47	19.99	39.98	59.97	80.0	100.0	120.0	139.9	159.9	179.9	219.9	47
48	20.02	40.04	60.05	80.1	100.1	120.1	140.1	160.1	180.2	220.2	48
49	20.04	40.09	60.13	80.2	100.2	120.3	140.3	160.4	180.4	220.5	49
50	20.07	40.14	60.21	80.3	100.4	120.4	140.5	160.6	180.6	220.8	50
51	20.10	40.20	60.29	80.4	100.5	120.6	140.7	160.8	180.9	221.1	51
52	20.12	40.25	60.37	80.5	100.6	120.7	140.9	161.0	181.1	221.4	52
53	20.15	40.30	60.45	80.6	100.8	120.9	141.0	161.2	181.4	221.7	53
54	20.18	40.36	60.53	80.7	100.9	121.1	141.2	161.4	181.6	222.0	54
55	20.20	40.41	60.61	80.8	101.0	121.2	141.4	161.6	181.8	222.2	55
56	20.23	40.46	60.69	80.9	101.2	121.4	141.6	161.8	182.1	222.5	56
57	20.26	40.51	60.77	81.0	101.3	121.5	141.8	162.1	182.3	222.8	57
58	20.28	40.57	60.85	81.1	101.4	121.7	142.0	162.3	182.6	223.1	58
59	20.31	40.62	60.93	81.2	101.6	121.9	142.2	162.5	182.8	223.4	59
Horz. Dist	96.03	192.1	288.1	384.1	480.2	576	672	768	864	1056	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .113 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

12°

′	100	200	300	400	500	600	700	800	900	1100	′
0	20.34	40.67	61.01	81.3	101.7	122.0	142.4	162.7	183.0	223.7	0
1	20.36	40.73	61.09	81.4	101.8	122.2	142.5	162.9	183.3	224.0	1
2	20.39	40.78	61.17	81.6	102.0	122.3	142.7	163.1	183.5	224.3	2
3	20.42	40.83	61.25	81.7	102.1	122.5	142.9	163.3	183.7	224.6	3
4	20.44	40.89	61.33	81.8	102.2	122.7	143.1	163.5	184.0	224.9	4
5	20.47	40.94	61.41	81.9	102.4	122.8	143.3	163.8	184.2	225.2	5
6	20.50	40.99	61.49	82.0	102.5	123.0	143.5	164.0	184.5	225.5	6
7	20.52	41.04	61.57	82.1	102.6	123.1	143.7	164.2	184.7	225.8	7
8	20.55	41.10	61.65	82.2	102.8	123.3	143.8	164.4	184.9	226.0	8
9	20.58	41.15	61.73	82.3	102.9	123.4	144.0	164.6	185.2	226.3	9
10	20.60	41.20	61.81	82.4	103.0	123.6	144.2	164.8	185.4	226.6	10
11	20.63	41.26	61.89	82.5	103.1	123.8	144.4	165.0	185.7	226.9	11
12	20.66	41.31	61.97	82.6	103.3	123.9	144.6	165.2	185.9	227.2	12
13	20.68	41.36	62.04	82.7	103.4	124.1	144.8	165.4	186.1	227.5	13
14	20.71	41.42	62.12	82.8	103.5	124.2	145.0	165.7	186.4	227.8	14
15	20.73	41.47	62.20	82.9	103.7	124.4	145.1	165.9	186.6	228.1	15
16	20.76	41.52	62.28	83.0	103.8	124.6	145.3	166.1	186.8	228.4	16
17	20.79	41.58	62.36	83.2	103.9	124.7	145.5	166.3	187.1	228.7	17
18	20.81	41.63	62.44	83.3	104.1	124.9	145.7	166.5	187.3	229.9	18
19	20.84	41.68	62.52	83.4	104.2	125.0	145.9	166.7	187.6	229.2	19
20	20.87	41.73	62.60	83.5	104.3	125.2	146.1	166.9	187.8	229.5	20
21	20.89	41.79	62.68	83.6	104.5	125.4	146.2	167.2	188.0	229.8	21
22	20.92	41.84	62.76	83.7	104.6	125.5	146.4	167.4	188.3	230.1	22
23	20.95	41.89	62.84	83.8	104.7	125.7	146.6	167.6	188.5	230.4	23
24	20.97	41.94	62.92	83.9	104.9	125.8	146.8	167.8	188.8	230.7	24
25	21.00	42.00	63.00	84.0	105.0	126.0	147.0	168.0	189.0	231.0	25
26	21.03	42.05	63.08	84.1	105.1	126.2	147.2	168.2	189.2	231.3	26
27	21.05	42.10	63.16	84.2	105.3	126.3	147.4	168.4	189.5	231.6	27
28	21.08	42.16	63.23	84.3	105.4	126.5	147.6	168.6	189.7	231.9	28
29	21.10	42.21	63.31	84.4	105.5	126.6	147.7	168.8	189.9	232.2	29
30	21.13	42.26	63.39	84.5	105.7	126.8	147.9	169.0	190.2	232.4	30
31	21.16	42.32	63.47	84.6	105.8	127.0	148.1	169.3	190.4	232.7	31
32	21.18	42.37	63.55	84.7	105.9	127.1	148.3	169.5	190.6	233.0	32
33	21.21	42.42	63.63	84.8	106.0	127.3	148.5	169.7	190.9	233.3	33
34	21.24	42.47	63.71	85.0	106.2	127.4	148.7	169.9	191.1	233.6	34
35	21.26	42.52	63.79	85.0	106.3	127.6	148.8	170.1	191.4	233.9	35
36	21.29	42.58	63.87	85.2	106.4	127.7	149.0	170.3	191.6	234.2	36
37	21.32	42.63	63.95	85.3	106.6	127.9	149.2	170.5	191.8	234.5	37
38	21.34	42.68	64.02	85.4	106.7	128.0	149.4	170.7	192.1	234.8	38
39	21.37	42.74	64.10	85.5	106.8	128.2	149.6	170.9	192.3	235.0	39
40	21.39	42.79	64.18	85.6	107.0	128.4	149.8	171.2	192.6	235.3	40
41	21.42	42.84	64.26	85.7	107.1	128.5	149.9	171.4	192.8	235.6	41
42	21.45	42.89	64.34	85.8	107.2	128.7	150.1	171.6	193.0	235.9	42
43	21.47	42.95	64.42	85.9	107.4	128.8	150.3	171.8	193.3	236.2	43
44	21.50	43.00	64.50	86.0	107.5	129.0	150.5	172.0	193.5	236.5	44
45	21.53	43.05	64.58	86.1	107.6	129.2	150.7	172.2	193.7	236.8	45
46	21.55	43.10	64.66	86.2	107.8	129.3	150.9	172.4	194.0	237.1	46
47	21.58	43.16	64.73	86.3	107.9	129.5	151.0	172.6	194.2	237.4	47
48	21.60	43.21	64.81	86.4	108.0	129.6	151.2	172.8	194.4	237.6	48
49	21.63	43.26	64.89	86.5	108.2	129.8	151.4	173.0	194.7	237.9	49
50	21.66	43.31	64.97	86.6	108.3	129.9	151.6	173.2	194.9	238.2	50
51	21.68	43.37	65.05	86.7	108.4	130.1	151.8	173.5	195.2	238.5	51
52	21.71	43.42	65.13	86.8	108.6	130.2	152.0	173.7	195.4	238.8	52
53	21.74	43.47	65.21	86.9	108.7	130.4	152.2	173.9	195.6	239.1	53
54	21.76	43.52	65.28	87.0	108.8	130.6	152.3	174.1	195.8	239.4	54
55	21.79	43.58	65.36	87.2	108.9	130.7	152.5	174.3	196.1	239.7	55
56	21.81	43.63	65.44	87.3	109.1	130.9	152.7	174.5	196.3	240.0	56
57	21.84	43.68	65.52	87.4	109.2	131.0	152.9	174.7	196.6	240.2	57
58	21.87	43.73	65.60	87.5	109.3	131.2	153.1	174.9	196.8	240.5	58
59	21.89	43.78	65.68	87.6	109.5	131.4	153.2	175.1	197.0	240.8	59
Horz. Dist.	95.32	190.6	286.0	381.3	476.6	572	667	763	858	1048	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .123 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*
DIFFERENCES IN ELEVATION
13°

′	100	200	300	400	500	600	700	800	900	1100	′
0	21.92	43.84	65.76	87.7	109.6	131.5	153.4	175.4	197.3	241.1	0
1	21.94	43.89	65.83	87.8	109.7	131.7	153.6	175.6	197.5	241.4	1
2	21.97	43.94	65.91	87.9	109.9	131.8	153.8	175.8	197.7	241.7	2
3	22.00	43.99	65.99	88.0	110.0	132.0	154.0	176.0	198.0	242.0	3
4	22.02	44.05	66.07	88.1	110.1	132.1	154.2	176.2	198.2	242.2	4
5	22.05	44.10	66.15	88.2	110.2	132.3	154.3	176.4	198.4	242.5	5
6	22.08	44.15	66.23	88.3	110.4	132.4	154.5	176.6	198.7	242.8	6
7	22.10	44.20	66.30	88.4	110.5	132.6	154.7	176.8	198.9	243.1	7
8	22.13	44.26	66.38	88.5	110.6	132.8	154.9	177.0	199.2	243.4	8
9	22.15	44.31	66.46	88.6	110.8	132.9	155.1	177.2	199.4	243.7	9
10	22.18	44.36	66.54	88.7	110.9	133.1	155.3	177.4	199.6	244.0	10
11	22.21	44.41	66.62	88.8	111.0	133.2	155.4	177.6	199.8	244.3	11
12	22.23	44.46	66.70	88.9	111.2	133.4	155.6	177.9	200.1	244.6	12
13	22.26	44.52	66.77	89.0	111.3	133.6	155.8	178.1	200.3	244.8	13
14	22.28	44.57	66.85	89.1	111.4	133.7	156.0	178.3	200.6	245.1	14
15	22.31	44.62	66.93	89.2	111.6	133.9	156.2	178.5	200.8	245.4	15
16	22.34	44.67	67.01	89.3	111.7	134.0	156.4	178.7	201.0	245.7	16
17	22.36	44.72	67.09	89.4	111.8	134.2	156.5	178.9	201.3	246.0	17
18	22.39	44.78	67.16	89.6	111.9	134.3	156.7	179.1	201.5	246.3	18
19	22.41	44.83	67.24	89.7	112.1	134.5	156.9	179.3	201.7	246.6	19
20	22.44	44.88	67.32	89.8	112.2	134.6	157.1	179.5	202.0	246.8	20
21	22.47	44.93	67.40	89.9	112.3	134.8	157.3	179.7	202.2	247.1	21
22	22.49	44.98	67.48	90.0	112.5	135.0	157.4	179.9	202.4	247.4	22
23	22.52	45.04	67.55	90.1	112.6	135.1	157.6	180.1	202.7	247.7	23
24	22.54	45.09	67.63	90.2	112.7	135.3	157.8	180.4	202.9	248.0	24
25	22.57	45.14	67.71	90.3	112.8	135.4	158.0	180.6	203.1	248.3	25
26	22.60	45.19	67.79	90.4	113.0	135.6	158.2	180.8	203.4	248.6	26
27	22.62	45.24	67.86	90.5	113.1	135.7	158.4	181.0	203.6	248.8	27
28	22.65	45.30	67.94	90.6	113.2	135.9	158.5	181.2	203.8	249.1	28
29	22.67	45.35	68.02	90.7	113.4	136.0	158.7	181.4	204.1	249.4	29
30	22.70	45.40	68.10	90.8	113.5	136.2	158.9	181.6	204.3	249.7	30
31	22.73	45.45	68.18	90.9	113.6	136.4	159.1	181.8	204.5	250.0	31
32	22.75	45.50	68.25	91.0	113.8	136.5	159.3	182.0	204.8	250.3	32
33	22.78	45.55	68.33	91.1	113.9	136.7	159.4	182.2	205.0	250.6	33
34	22.80	45.61	68.41	91.2	114.0	136.8	159.6	182.4	205.2	250.8	34
35	22.83	45.66	68.49	91.3	114.1	137.0	159.8	182.6	205.5	251.1	35
36	22.86	45.71	68.56	91.4	114.3	137.1	160.0	182.8	205.7	251.4	36
37	22.88	45.76	68.64	91.5	114.4	137.3	160.2	183.0	205.9	251.7	37
38	22.91	45.81	68.72	91.6	114.5	137.4	160.4	183.2	206.2	252.0	38
39	22.94	45.88	68.81	91.8	114.7	137.6	160.6	183.5	206.4	252.3	39
40	22.96	45.92	68.88	91.8	114.8	137.8	160.7	183.7	206.6	252.5	40
41	22.98	45.97	68.95	91.9	114.9	137.9	160.9	183.9	206.9	252.8	41
42	23.01	46.02	69.03	92.0	115.0	138.1	161.1	184.1	207.1	253.1	42
43	23.04	46.07	69.11	92.1	115.2	138.2	161.2	184.3	207.3	253.4	43
44	23.06	46.12	69.18	92.2	115.3	138.4	161.4	184.5	207.6	253.7	44
45	23.09	46.18	69.26	92.4	115.4	138.5	161.6	184.7	207.8	254.0	45
46	23.11	46.23	69.34	92.4	115.6	138.7	161.8	184.9	208.0	254.2	46
47	23.14	46.28	69.42	92.6	115.7	138.8	162.0	185.1	208.2	254.5	47
48	23.15	46.30	69.46	92.6	115.8	138.9	162.1	185.2	208.4	254.7	48
49	23.19	46.38	69.57	92.8	116.0	139.1	162.3	185.5	208.7	255.1	49
50	23.22	46.43	69.65	92.9	116.1	139.3	162.5	185.7	209.0	255.4	50
51	23.24	46.48	69.73	93.0	116.2	139.4	162.7	185.9	209.2	255.7	51
52	23.27	46.54	69.81	93.1	116.3	139.6	162.9	186.2	209.4	256.0	52
53	23.29	46.59	69.88	93.2	116.5	139.8	163.0	186.4	209.6	256.2	53
54	23.32	46.64	69.96	93.3	116.6	139.9	163.2	186.6	209.9	256.5	54
55	23.34	46.69	70.04	93.4	116.7	140.1	163.4	186.8	210.1	256.8	55
56	23.37	46.74	70.11	93.5	116.9	140.2	163.6	187.0	210.3	257.1	56
57	23.40	46.79	70.19	93.6	117.0	140.4	163.8	187.2	210.6	257.4	57
58	23.42	46.84	70.27	93.7	117.1	140.5	164.0	187.4	210.8	257.6	58
59	23.45	46.90	70.34	93.8	117.2	140.7	164.1	187.6	211.0	257.9	59
Horz. Dist.	94.55	189.1	283.6	378.2	472.8	567	662	756	851	1040	Horz. Dist.

Hor. dist. *is for 30′* point. Add or subtract .132 ft. to each 100 ft. of distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

14°

′	100	200	300	400	500	600	700	800	900	1100	′
0	23.47	47.00	70.42	93.9	117.4	140.8	164.3	187.8	211.3	258.2	0
1	23.50	47.00	70.50	94.0	117.5	141.0	164.5	188.0	211.5	258.5	1
2	23.52	47.05	70.58	94.1	117.6	141.2	164.7	188.2	211.7	258.8	2
3	23.55	47.10	70.65	94.2	117.8	141.3	164.8	188.4	212.0	259.1	3
4	23.58	47.15	70.73	94.3	117.9	141.5	165.0	188.6	212.2	259.3	4
5	23.60	47.20	70.81	94.4	118.0	141.6	165.2	188.8	212.4	259.6	5
6	23.63	47.25	70.88	94.5	118.1	141.8	165.4	189.0	212.6	259.9	6
7	23.65	47.31	70.96	94.6	118.3	141.9	165.6	189.2	212.9	260.2	7
8	23.68	47.36	71.04	94.7	118.4	142.1	165.8	189.4	213.1	260.5	8
9	23.70	47.41	71.11	94.8	118.5	142.2	165.9	189.6	213.3	260.8	9
10	23.73	47.46	71.19	94.9	118.6	142.4	166.1	189.8	213.6	261.0	10
11	23.76	47.51	71.27	95.0	118.8	142.5	166.3	190.0	213.8	261.3	11
12	23.78	47.56	71.34	95.1	118.9	142.7	166.5	190.2	214.0	261.6	12
13	23.81	47.61	71.42	95.2	119.0	142.8	166.6	190.5	214.3	261.9	13
14	23.83	47.66	71.50	95.3	119.2	143.0	166.8	190.7	214.5	262.2	14
15	23.86	47.72	71.57	95.4	119.3	143.2	167.0	190.9	214.7	262.4	15
16	23.88	47.77	71.65	95.5	119.4	143.3	167.2	191.1	215.0	262.7	16
17	23.91	47.82	71.73	95.6	119.6	143.4	167.4	191.3	215.2	263.0	17
18	23.94	47.87	71.80	95.7	119.7	143.6	167.5	191.5	215.4	263.3	18
19	23.96	47.92	71.88	95.8	119.8	143.8	167.7	191.7	215.6	263.6	19
20	23.98	47.97	72.00	95.9	119.9	143.9	167.9	191.9	215.9	263.8	20
21	24.01	48.02	72.03	96.0	120.1	144.1	168.1	192.1	216.1	264.1	21
22	24.04	48.07	72.11	96.2	120.2	144.2	168.3	192.3	216.3	264.4	22
23	24.06	48.12	72.19	96.2	120.3	144.4	168.4	192.5	216.6	264.7	23
24	24.09	48.18	72.26	96.4	120.4	144.5	168.6	192.7	216.8	265.0	24
25	24.11	48.23	72.34	96.4	120.6	144.7	168.8	192.9	217.0	265.2	25
26	24.14	48.28	72.42	96.6	120.7	144.8	169.0	193.1	217.2	265.5	26
27	24.16	48.33	72.49	96.7	120.8	145.0	169.2	193.3	217.5	265.8	27
28	24.19	48.38	72.57	96.8	121.0	145.1	169.3	193.5	217.7	266.1	28
29	24.22	48.43	72.64	96.9	121.1	145.3	169.5	193.7	217.9	266.4	29
30	24.24	48.48	72.72	97.0	121.2	145.4	169.7	193.9	218.2	266.6	30
31	24.27	48.53	72.80	97.1	121.3	145.6	169.9	194.1	218.4	266.9	31
32	24.29	48.58	72.88	97.2	121.5	145.8	170.0	194.3	218.6	267.2	32
33	24.32	48.63	72.95	97.3	121.6	145.9	170.2	194.5	218.8	267.5	33
34	24.34	48.68	73.03	97.4	121.7	146.0	170.4	194.7	219.1	267.8	34
35	24.37	48.74	73.10	97.5	121.8	146.2	170.6	194.9	219.3	268.0	35
36	24.39	48.79	73.18	97.6	122.0	146.4	170.8	195.1	219.5	268.3	36
37	24.42	48.84	73.26	97.7	122.1	146.5	170.9	195.4	219.8	268.6	37
38	24.44	48.89	73.33	97.8	122.2	146.7	171.1	195.6	220.0	268.9	38
39	24.47	48.94	73.41	97.9	122.4	146.8	171.3	195.8	220.2	269.2	39
40	24.50	48.99	73.48	98.0	122.5	147.0	171.5	196.0	220.4	269.4	40
41	24.52	49.04	73.56	98.1	122.6	147.1	171.6	196.2	220.7	269.7	41
42	24.54	49.09	73.64	98.2	122.7	147.3	171.8	196.4	220.9	270.0	42
43	24.57	49.14	73.71	98.3	122.8	147.4	172.0	196.6	221.1	270.3	43
44	24.60	49.19	73.79	98.4	123.0	147.6	172.2	196.8	221.4	270.6	44
45	24.62	49.24	73.86	98.5	123.1	147.7	172.4	197.0	221.6	270.8	45
46	24.65	49.29	73.94	98.6	123.2	147.9	172.5	197.2	221.8	271.1	46
47	24.67	49.34	74.02	98.7	123.4	148.0	172.7	197.4	222.1	271.4	47
48	24.70	49.39	74.09	98.8	123.5	148.2	172.9	197.6	222.3	271.7	48
49	24.72	49.44	74.17	98.9	123.6	148.3	173.1	197.8	222.5	272.0	49
30	24.75	49.50	74.24	99.0	123.7	148.5	173.2	198.0	222.7	272.2	50
51	24.77	49.55	74.32	99.1	123.9	148.6	173.4	198.2	223.0	272.5	51
52	24.80	49.60	74.39	99.2	124.0	148.8	173.6	198.4	223.2	272.8	52
53	24.82	49.65	74.47	99.3	124.1	148.9	173.8	198.6	223.4	273.1	53
54	24.85	49.70	74.55	99.4	124.2	149.1	173.9	198.8	223.6	273.3	54
55	24.87	49.75	74.62	99.5	124.4	140.2	174.1	199.0	223.9	273.6	55
56	24.90	49.80	74.70	99.6	124.5	149.4	174.3	199.2	224.1	273.9	56
57	24.92	49.85	74.77	99.7	124.6	149.6	174.5	199.4	224.3	274.2	57
58	24.95	49.90	74.85	99.8	124.8	149.7	174.6	199.6	224.6	274.4	58
59	24.98	49.95	74.92	99.9	124.9	149.8	174.8	199.8	224.8	274.7	59
Horz. Dist.	93.73	187.5	281.2	374.9	468.6	562	656	750	844	1031	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .141 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—*Continued*

DIFFERENCES IN ELEVATION

15°

′	100	200	300	400	500	600	700	800	900	1100	′
0	25.00	50.00	75.00	100.0	125.0	150.0	175.0	200.0	225.0	275.0	0
1	25.02	50.05	75.08	100.1	125.2	150.2	175.2	200.2	225.3	275.3	1
2	25.05	50.10	75.15	100.2	125.2	150.3	175.4	200.4	225.5	275.6	2
3	25.08	50.15	75.23	100.3	125.4	150.4	175.5	200.6	225.7	275.8	3
4	25.10	50.20	75.30	100.4	125.5	150.6	175.7	200.8	225.9	276.1	4
5	25.13	50.25	75.38	100.5	125.6	150.8	175.9	201.0	226.1	276.4	5
6	25.15	50.30	75.45	100.6	125.8	150.9	176.0	201.2	226.4	276.6	6
7	25.18	50.35	75.53	100.7	125.9	151.1	176.2	201.4	226.6	276.9	7
8	25.20	50.40	75.60	100.8	126.0	151.2	176.4	201.6	226.8	277.2	8
9	25.23	50.45	75.68	100.9	126.1	151.4	176.6	201.8	227.0	277.5	9
10	25.25	50.50	75.76	101.0	126.3	151.5	176.8	202.0	227.3	277.8	10
11	25.28	50.55	75.83	101.1	126.4	151.7	176.9	202.2	227.5	278.0	11
12	25.30	50.60	75.90	101.2	126.5	151.8	177.1	202.4	227.7	278.3	12
13	25.33	50.65	75.98	101.3	126.6	152.0	177.3	202.6	227.9	278.6	13
14	25.35	50.70	76.06	101.4	126.8	152.1	177.5	202.8	228.2	278.9	14
15	25.38	50.75	76.13	101.5	126.9	152.3	177.6	203.0	228.4	279.2	15
16	25.40	50.80	76.21	101.6	127.0	152.4	177.8	203.2	228.6	279.4	16
17	25.43	50.85	76.28	101.7	127.1	152.6	178.0	203.4	228.8	279.7	17
18	25.45	50.90	76.36	101.8	127.3	152.7	178.2	203.6	229.1	280.0	18
19	25.48	50.95	76.43	101.9	127.4	152.9	178.3	203.8	229.3	280.2	19
20	25.50	51.00	76.51	102.0	127.5	153.0	178.5	204.0	229.5	280.5	20
21	25.53	51.05	76.58	102.1	127.6	153.2	178.7	204.2	229.7	280.8	21
22	25.55	51.10	76.66	102.2	127.8	153.3	178.9	204.4	230.0	281.1	22
23	25.58	51.15	76.73	102.3	127.9	153.5	179.0	204.6	230.2	281.2	23
24	25.60	51.[illegible]0	76.81	102.4	128.0	153.6	179.2	204.8	230.4	281.6	24
25	25.63	51.25	76.88	102.5	128.1	153.8	179.4	205.0	230.6	281.9	25
26	25.65	51.30	76.95	102.6	128.3	153.9	179.6	205.2	230.9	282.2	26
27	25.68	51.35	77.03	102.7	128.4	154.1	179.7	205.4	231.1	282.4	27
28	25.70	51.40	77.11	102.8	128.5	154.2	179.9	205.6	231.3	282.7	28
29	25.73	51.45	77.18	102.9	128.6	154.4	180.1	205.8	231.5	283.0	29
30	25.75	51.50	77.26	103.0	128.8	154.5	180.3	206.0	231.8	283.3	30
31	25.78	51.55	77.33	103.1	128.9	154.7	180.4	206.2	232.0	283.6	31
32	25.80	51.60	77.41	103.2	129.0	154.8	180.6	206.4	232.2	283.8	32
33	25.83	51.65	77.48	103.3	129.1	155.0	180.8	206.6	232.4	284.1	33
34	25.85	51.70	77.56	103.4	129.3	155.1	181.0	206.8	232.7	284.4	34
35	25.88	51.75	77.63	103.5	129.4	155.3	181.1	207.0	232.9	284.6	35
36	25.90	51.80	77.70	103.6	129.5	155.4	181.3	207.2	233.1	284.9	36
37	25.93	51.85	77.78	103.7	129.6	155.6	181.5	207.4	233.3	285.2	37
38	25.95	51.90	77.85	103.8	129.8	155.7	181.7	207.6	233.6	285.5	38
39	25.98	51.95	77.93	103.9	129.9	155.9	181.8	207.8	233.8	285.7	39
40	26.00	52.00	78.00	104.0	130.0	156.0	182.0	208.0	234.0	286.0	40
41	26.02	52.05	78.08	104.1	130.2	156.2	182.2	208.2	234.3	286.3	41
42	26.05	52.10	78.15	104.2	130.2	156.3	182.4	208.4	234.5	286.6	42
43	26.08	52.15	78.23	104.3	130.4	156.4	182.5	208.6	234.7	286.8	43
44	26.10	52.20	78.30	104.4	130.5	156.6	182.7	208.8	234.9	287.1	44
45	26.12	52.25	78.38	104.5	130.6	156.8	182.9	209.0	235.1	287.4	45
46	26.15	52.30	78.45	104.6	130.8	156.9	183.0	209.2	235.4	287.6	46
47	26.18	52.35	78.52	104.7	130.9	157.0	183.2	209.4	235.6	287.9	47
48	26.20	52.40	78.60	104.8	131.0	157.2	183.4	209.6	235.8	288.2	48
49	26.22	52.45	78.67	104.9	131.1	157.3	183.6	209.8	236.0	288.5	49
50	26.25	52.50	78.75	105.0	131.2	157.5	183.7	210.0	236.2	288.7	50
51	26.27	52.55	78.82	105.1	131.4	157.6	183.9	210.2	236.5	289.0	51
52	26.30	52.60	78.90	105.2	131.5	157.8	184.1	210.4	236.7	289.3	52
53	26.32	52.65	78.97	105.3	131.6	157.9	184.3	210.6	236.9	289.6	53
54	26.35	52.70	79.04	105.4	131.7	158.1	184.4	210.8	237.1	289.8	54
55	26.37	52.74	79.12	105.5	131.9	158.2	184.6	211.0	237.4	290.1	55
56	26.40	52.79	79.19	105.6	132.0	158.4	184.8	211.2	237.6	290.4	56
57	26.42	52.84	79.27	105.7	132.1	158.5	185.0	211.4	237.8	290.6	57
58	26.45	52.89	79.34	105.8	132.2	158.7	185.1	211.6	238.0	290.9	58
59	26.47	52.94	79.42	105.9	132.4	158.8	185.3	211.8	238.2	291.2	59
Horz. Dist.	92.86	185.7	278.6	371.4	464.3	557	650	743	836	1022	Horz. Dist.

Hor. dist. *is* for 30′ point. Add or subtract .150 ft. to each 100 ft. of distance for each 10′ departure.

TABLE 7—Continued

DIFFERENCES IN ELEVATION

16°

′	100	200	300	400	500	600	700	800	900	1100	′
0	26 50	52 99	79 45	106 0	132.5	159.0	185 5	212.0	238.5	291.5	0
1	26.52	53 04	79.56	106.1	132.6	159.1	185.6	212.2	238.7	291.7	1
2	26.55	53 09	79 64	106.2	132.7	159.3	185.8	212.4	238.9	292.0	2
3	26 57	53 14	79 71	106 3	132.8	159 4	186.0	212.6	239.1	292.3	3
4	26.60	53.19	79 78	106.4	133.0	159.6	186.2	212.8	239.4	292.5	4
5	26 62	53 24	79 86	106 5	133.1	159.7	186.3	213.0	239.6	292.8	5
6	26.64	53 29	79 90	106 6	133.2	159.9	186.5	213.2	239.8	293.1	6
7	26 67	53 34	80 01	106 7	133.3	160.0	186.7	213.4	240.0	293.4	7
8	26 69	53 39	80 08	106 8	133.5	160.2	186 8	213.5	240.2	293.6	8
9	26.72	53 44	80 15	106 9	133.6	160 3	187.0	213.7	240.5	293.9	9
10	26.74	53 48	80 23	107 0	133 7	160.4	187.2	213.9	240.7	294.2	10
11	26 77	53 51	80 30	107 1	133 8	160.6	187.4	214.1	240.9	294.4	11
12	26 79	53 58	80 38	107 2	134.0	160 8	187.5	214 3	241.1	294.7	12
13	26 82	51 61	80 45	107 3	134 1	160 9	187 7	214 5	241.3	295.0	13
14	26 84	51 68	80 52	107 4	134 2	161 0	187 9	214 7	241.6	295.2	14
15	26 86	53 73	80 60	107 5	134 3	161.2	188.1	214 9	241.8	295.5	15
16	26 89	53 78	80 67	107 6	134 4	161 3	188.2	215 1	242.0	295.8	16
17	26.91	53 83	80 74	107 7	134 6	161 5	188.4	215.3	242.2	296.0	17
18	26 94	53 88	80 82	107.8	134 7	161 6	188 6	215 5	242.4	296.3	18
19	26 96	53.93	80 89	107 9	134 8	161 8	188 7	215 7	242 7	296.6	19
20	26 99	53 98	80 96	108 0	134 9	161 9	188 9	215 9	242.9	296.9	20
21	27.01	54.03	81 04	108 0	135 1	162.1	189.1	216 1	243.1	297.1	21
22	27 04	54 07	81 11	108 1	135 2	162 2	189 3	216 3	243.3	297.4	22
23	27 06	54 12	81 18	108 2	135 3	162 4	189 4	216 5	243 6	297.7	23
24	27 09	54 17	81.26	108.3	135.4	162 5	189 6	216 7	243 8	297.9	24
25	27 11	54 22	81 33	108.4	135 6	162 7	189 8	216 9	244 0	298.2	25
26	27 13	54 26	81 40	108.5	135 6	162.8	189 9	217 0	244 2	298.4	26
27	27.16	54 32	81 48	108 6	135 8	163 0	190 1	217 3	244 4	298.7	27
28	27 18	54.37	81 55	108 7	135 9	163.1	190 3	217 5	244 6	299.0	28
29	27 21	54 41	81 62	108 8	136 0	163 2	190 4	217 7	244 9	299.3	29
30	27 23	54 46	81.70	108 9	136 2	163 4	190 6	217 9	245 1	299.6	30
31	27.26	54 51	81 77	109 0	136 3	163 5	190 8	218 0	245 3	299.8	31
32	27 28	54 56	81 84	109 1	136 4	163.7	191 0	218 2	245 5	300 1	32
33	27 30	54 61	81 92	109 2	136.5	163 8	191.1	218 4	245 8	300 4	33
34	27 33	54 66	81 99	109.3	136 6	164.0	191 3	218 6	246 0	300 6	34
35	27 35	54.71	82.10	109 4	136.8	164.1	191.5	218 8	246 2	300 9	35
36	27 38	54 76	82.13	109.5	136 9	164.3	191.6	219.0	246 4	301 2	36
37	27.40	54 80	82 21	109 6	137.0	164.4	191.8	219 2	246 6	301 4	37
38	27.43	54.85	82.28	109 7	137 1	164.6	192 0	219.4	246.8	301.7	38
39	27.45	54.90	82 35	109 8	137.3	164 7	192.2	219.6	247.1	302 0	39
40	27.48	54 95	82 43	109.9	137.4	164.8	192.3	219.8	247 3	302 2	40
41	27.50	55.00	82.50	110.0	137.5	165.0	192.5	220.0	247.5	302 5	41
42	27.52	55 05	82.57	110 1	137.6	165 1	192.7	220 2	247.7	302 8	42
43	27.55	55 10	82.60	110.2	137.7	165.3	192.8	220.4	247.9	303 0	43
44	27.57	55.14	82 72	110.3	137.9	165.4	193 0	220.6	248.2	303.3	44
45	27 60	55 19	82 79	110.4	138.0	165.6	193.2	220.8	248.4	303 6	45
46	27.62	55.24	82.86	110 5	138.1	165 7	193.4	221.0	248.6	303 8	46
47	27 65	55 29	82 94	110.6	138.2	165.9	193.5	221.2	248.8	304 1	47
48	27 67	55 34	83 01	110 7	138 4	166 0	193.7	221.4	249 0	304 4	48
49	27.69	55 39	83 08	110 8	138.5	166.2	193.9	221.6	249.2	304.6	49
50	27.72	55 44	83.15	110.9	138.6	166.3	194.0	221.7	249.5	304.9	50
51	27.74	55 48	83 23	111.0	138.7	166.4	194 2	221.9	249.7	305.2	51
52	27 77	55 53	83.30	111.1	138.8	166 6	194.4	222.1	249.9	305 4	52
53	27 79	55 58	83 37	111 2	139.0	166 7	194 5	222.3	250.1	305.7	53
54	27.82	55 63	83.44	111.3	139 1	166 9	194.7	222.5	250.3	306.0	54
55	27 84	55.68	83 52	111.4	139.2	167 0	194.9	222.7	250.6	306.2	55
56	27.86	55.73	83.59	111.4	139.3	167 2	195.0	222.9	250.8	306.5	56
57	27.89	55 78	83.66	111.6	139 4	167.3	195.2	223.1	251.0	306.8	57
58	27.91	55 82	83 74	111 6	139.6	167.5	195 4	223.3	251.2	307 0	58
59	27.94	55 87	83 81	111.7	139 7	167 6	195.6	223.5	251.4	307.3	59
Horz. Dist	91.93	183 9	275 8	367.7	459.7	552	644	735	827	1011	Horz. Dist.

Hor. dist. is for 30′ point. Add or subtract .158 ft. to each 100 ft. distance for each 10′ departure.

Table 7—*Continued*

DIFFERENCES IN ELEVATION

17° to 23°

′	17°	18°	19°	20°	21°	22°	23°	′
0	27.96	29.39	30.78	32.14	33.46	34.73	35.97	0
1	27.99	29.42	30.81	32.16	33.48	34.75	35.99	1
2	28.01	29.44	30.83	32.18	33.50	34.77	36.01	2
3	28.04	29.47	30.85	32.21	33.52	34.80	36.03	3
4	28.06	29.49	30.87	32.23	33.54	34.82	36.05	4
5	28.08	29.51	30.90	32.25	33.57	34.84	36.07	5
6	28.10	29.53	30.92	32.27	33.59	34.86	36.09	6
7	28.13	29.56	30.94	32.30	33.61	34.88	36.11	7
8	28.15	29.58	30.97	32.32	33.63	34.90	36.13	8
9	28.18	29.60	30.99	32.34	33.65	34.92	36.15	9
10	28.20	29.62	31.01	32.36	33.67	34.94	36.17	10
11	28.22	29.65	31.04	32.39	33.70	34.96	36.19	11
12	28.25	29.67	31.06	32.41	33.72	34.98	36.21	12
13	28.27	29.69	31.08	32.43	33.74	35.00	36.23	13
14	28.30	29.72	31.10	32.45	33.76	35.02	36.25	14
15	28.32	29.74	31.13	32.47	33.78	35.05	36.27	15
16	28.34	29.76	31.15	32.49	33.80	35.07	36.29	16
17	28.37	29.79	31.17	32.51	33.82	35.09	36.31	17
18	28.39	29.81	31.19	32.54	33.84	35.11	36.33	18
19	28.42	29.83	31.22	32.56	33.87	35.13	36.35	19
20	28.44	29.86	31.24	32.58	33.89	35.15	36.37	20
21	28.47	29.88	31.26	32.61	33.91	35.17	36.39	21
22	28.49	29.90	31.28	32.63	33.93	35.19	36.41	22
23	28.51	29.93	31.30	32.65	33.95	35.21	36.43	23
24	28.54	29.95	31.33	32.67	33.97	35.23	36.45	24
25	28.56	29.97	31.35	32.70	33.99	35.25	36.47	25
26	28.58	30.00	31.38	32.72	34.01	35.27	36.49	26
27	28.61	30.02	31.40	32.74	34.04	35.29	36.51	27
28	28.63	30.04	31.42	32.76	34.06	35.31	36.53	28
29	28.66	30.07	31.43	32.78	34.08	35.34	36.55	29
30	28.68	30.09	31.47	32.80	34.10	35.36	36.57	30
31	28.70	30.11	31.49	32.83	34.12	35.38	36.59	31
32	28.73	30.14	31.51	32.85	34.14	35.40	36.61	32
33	28.75	30.16	31.54	32.87	34.16	35.42	36.63	33
34	28.77	30.19	31.56	32.89	34.18	35.44	36.65	34
35	28.80	30.21	31.58	32.91	34.21	35.46	36.67	35
36	28.82	30.23	31.60	32.93	34.23	35.48	36.69	36
37	28.85	30.26	31.63	32.96	34.25	35.50	36.71	37
38	28.87	30.28	31.65	32.98	34.27	35.52	36.73	38
39	28.89	30.30	31.67	33.00	34.29	35.54	36.75	39
40	28.92	30.32	31.69	33.02	34.31	35.56	36.77	40
41	28.94	30.36	31.72	33.05	34.33	35.58	36.79	41
42	28.96	30.37	31.74	33.07	34.35	35.60	36.80	42
43	28.99	30.39	31.76	33.09	34.38	35.62	36.82	43
44	29.01	30.41	31.78	33.11	34.40	35.64	36.84	44
45	29.04	30.44	31.81	33.13	34.42	35.66	36.86	45
46	29.06	30.46	31.83	33.15	34.44	35.68	36.88	46
47	29.08	30.49	31.85	33.18	34.46	35.70	36.90	47
48	29.11	30.51	31.87	33.20	34.48	35.72	36.92	48
49	29.13	30.53	31.90	33.32	34.50	35.74	36.94	49
50	29.15	30.55	31.92	33.24	34.52	35.76	36.96	50
51	29.18	30.58	31.94	33.26	34.54	35.78	36.98	51
52	29.20	30.60	31.96	33.28	34.57	35.80	37.00	52
53	29.23	30.62	31.99	33.31	34.59	35.83	37.02	53
54	29.25	30.65	32.01	33.33	34.61	35.85	37.04	54
55	29.27	30.67	32.03	33.35	34.63	35.87	37.06	55
56	29.30	30.69	32.05	33.37	34.65	35.89	37.08	56
57	29.32	30.72	32.07	33.39	34.67	35.91	37.10	57
58	29.34	30.74	32.09	33.41	34.69	35.93	37.12	58
59	29.37	30.76	32.12	33.44	34.71	35.95	37.14	59
Horz. Dist.	90.96	89.93	88.86	87.74	86.57	85.36	84.10	Horz. Dist.
Horz. Corr.	.167	.175	.182	.191	.198	.206	.213	Horz. Corr.

Hor. correction is for 10′ each way from the 30′ point.
All Values are for a Rod Reading of 100 ft.

TABLE 7—*Concluded*

DIFFERENCES IN ELEVATION

24° to 29

′	24°	25°	26°	27°	28°	29°	′
0	37.16	38.30	39.49	40.45	41.45	42.40	0
1	37.18	38.32	39.42	40.47	41.47	42.42	1
2	37.20	38.34	39.44	40.49	41.48	42.43	2
3	37.22	38.36	39.46	40.51	41.50	42.45	3
4	37.23	38.38	39.47	40.52	41.52	42.46	4
5	37.25	38.40	39.49	40.54	41.54	42.48	5
6	37.27	38.41	39.51	40.55	41.55	42.49	6
7	37.29	38.43	39.51	40.57	41.57	42.51	7
8	37.31	38.45	39.55	40.59	41.58	42.53	8
9	37.33	38.47	39.56	40.61	41.60	42.54	9
10	37.35	38.49	39.58	40.62	41.61	42.56	10
11	37.37	38.52	39.60	40.64	41.63	42.58	11
12	37.39	38.53	39.61	40.66	41.65	42.59	12
13	37.41	38.55	39.63	40.68	41.67	42.60	13
14	37.43	38.56	39.65	40.69	41.68	42.62	14
15	37.45	35.58	39.67	40.71	41.70	42.64	15
16	37.47	38.60	39.69	40.72	41.71	42.65	16
17	37.49	38.62	39.71	40.74	41.73	42.66	17
18	37.51	38.64	39.72	40.76	41.74	42.68	18
19	37.53	38.66	39.74	40.78	41.76	42.70	19
20	37.54	38.67	39.76	40.79	41.77	42.71	20
21	37.56	38.69	39.78	40.81	41.79	42.72	21
22	37.58	38.71	39.79	40.82	41.81	42.74	22
23	37.60	38.73	39.82	40.84	41.83	42.76	23
24	37.62	38.75	39.83	40.86	41.84	42.77	24
25	37.64	38.76	39.85	40.88	41.86	42.78	25
26	37.66	38.78	39.86	40.89	41.87	42.80	26
27	37.68	38.80	39.88	40.91	41.89	42.82	27
28	37.70	38.82	39.90	40.92	41.90	42.83	28
29	37.72	38.84	39.92	20.94	41.92	42.85	29
30	37.74	38.86	39.93	40.96	41.93	42.86	30
31	37.76	38.88	39.95	40.98	41.95	42.88	31
32	37.77	38.89	39.97	40.99	41.97	42.89	32
33	37.79	38.91	39.99	41.01	41.99	42.91	33
34	37.81	38.93	40.00	41.02	42.00	42.92	34
35	37.83	38.95	40.02	41.04	42.02	42.94	35
36	37.85	38.97	40.04	41.06	42.03	42.95	36
37	37.87	38.99	40.06	41.08	42.05	42.97	37
38	37.89	39.00	40.07	41.09	42.06	42.98	38
39	37.91	39.02	40.09	41.11	42.08	43.00	39
40	37.93	39.04	40.11	41.12	42.09	43.01	40
41	37.95	39.06	40.13	41.14	42.11	43.03	41
42	37.96	39.08	40.14	41.16	42.12	43.04	42
43	37.98	39.10	40.16	41.18	42.14	43.06	43
44	38.00	39.11	40.18	41.19	42.15	43.07	44
45	38.02	39.13	40.20	41.21	42.17	43.09	45
46	38.04	39.15	40.21	41.22	42.19	43.10	46
47	38.06	39.17	40.23	41.24	42.21	43.12	47
48	38.08	39.18	40.24	41.26	42.22	43.13	48
49	38.10	39.20	40.26	41.28	42.24	43.15	49
50	38.11	39.22	40.28	41.29	42.25	43.16	50
51	38.13	39.24	40.30	41.31	42.26	43.17	51
52	38.15	39.26	40.31	41.32	42.28	43.18	52
53	38.17	39.27	40.33	41.34	42.30	43.20	53
54	38.19	39.29	40.35	41.35	42.31	43.21	54
55	38.21	39.31	40.37	41.37	42.33	43.23	55
56	38.23	39.33	40.38	41.39	42.34	43.24	56
57	38.25	39.35	40.40	41.41	42.36	43.26	57
58	38.26	39.36	40.42	41.42	42.37	43.27	58
59	38.28	39.38	40.44	41.43	42.39	43.29	59
Horz. Dist.	82.80	81.47	80.09	78.68	77.23	75.75	Horz. Dist.
Horz. Corr.	.219	.226	.233	.238	.244	.250	Horz. Corr.

Hor. correction is for 10′ each way from the 30′ point.
All Values are for a Rod Reading of 100 ft.

Conversion of Feet to Decimals of a Mile.

Table 8 is a table for the conversion of feet to decimals of a mile. A table of this character will be found convenient when the mile is the unit for platting. This table is reproduced by permission from publications of the U. S. Geological Survey.

For any distance expressed in feet which is likely to come into consideration in making a stadia survey the equivalent fraction of a mile is noted.

Table 8

CONVERSION OF FEET TO DECIMALS OF A MILE

(By permission of the U. S. Geological Survey)

Feet.	Mile.	Feet.	Mile.	Feet.	Mile.	Feet.	Mile.	Feet.	Mile.	Feet.	Mile.	Feet.	Mile.
100	0.019	600	0.114	1100	0.208	1600	0.303	2100	0.398	2600	0.492	3100	0.587
10	.021	10	.116	10	.210	10	.305	10	.400	10	.494	10	.589
20	.023	20	.118	20	.212	20	.307	20	.402	20	.496	20	.591
30	.025	30	.120	30	.214	30	.309	30	.404	30	.498	30	.593
40	.026	40	.122	40	.216	40	.311	40	.405	40	.500	40	.595
50	.028	50	.124	50	.218	50	.313	50	.407	50	.502	50	.596
60	.030	60	.125	60	.219	60	.314	60	.409	60	.504	60	.598
70	.032	70	.127	70	.221	70	.316	70	.411	70	.506	70	.600
80	.034	80	.129	80	.223	80	.318	80	.413	80	.508	80	.602
90	.036	90	.131	90	.225	90	.320	90	.415	90	.509	90	.604
200	.038	700	.133	1200	.227	1700	.322	2200	.417	2700	.511	3200	.606
10	.040	10	.134	10	.229	10	.324	10	.419	10	.513	10	.608
20	.042	20	.136	20	.231	20	.326	20	.420	20	.515	20	.610
30	.044	30	.138	30	.233	30	.328	30	.422	30	.517	30	.612
40	.046	40	.140	40	.235	40	.330	40	.424	40	.519	40	.614
50	.047	50	.142	50	.236	50	.331	50	.426	50	.521	50	.616
60	.049	60	.144	60	.238	60	.333	60	.428	60	.523	60	.617
70	.051	70	.146	70	.240	70	.335	70	.430	70	.525	70	.619
80	.053	80	.148	80	.242	80	.337	80	.432	80	.527	80	.621
90	.055	90	.150	90	.244	90	.339	90	.434	90	.529	90	.623
300	.057	800	.152	1300	.246	1800	.341	2300	.436	2800	.530	3300	.625
10	.059	10	.153	10	.248	10	.343	10	.438	10	.532	10	.627
20	.061	20	.155	20	.250	20	.345	20	.439	20	.534	20	.629
30	.062	30	.157	30	.252	30	.347	30	.441	30	.536	30	.631
40	.064	40	.159	40	.254	40	.349	40	.443	40	.538	40	.633
50	.066	50	.161	50	.256	50	.350	50	.445	50	.540	50	.644
60	.068	60	.163	60	.257	60	.352	60	.447	60	.542	60	.666
70	.070	70	.165	70	.259	70	.354	70	.449	70	.544	70	.688
80	.072	80	.167	80	.261	80	.356	80	.451	80	.546	80	.640
90	.074	90	.169	90	.263	90	.358	90	.453	90	.547	90	.642
400	.076	900	.170	1400	.265	1900	.360	2400	.455	2900	.549	3400	.644
10	.078	10	.172	10	.267	10	.362	10	.456	10	.551	10	.646
20	.080	20	.174	20	.269	20	.364	20	.458	20	.553	20	.648
30	.082	30	.176	30	.271	30	.366	30	.460	30	.555	30	.650
40	.084	40	.178	40	.273	40	.367	40	.462	40	.537	40	.652
50	.086	50	.180	50	.275	50	.369	50	.464	50	.559	30	.653
60	.088	60	.181	60	.276	60	.371	60	.466	60	.561	60	.655
70	.089	70	.183	70	.278	70	.373	70	.468	70	.562	70	.657
80	.091	80	.185	80	.280	80	.375	80	.470	80	.564	80	.659
90	.093	90	.187	90	.282	90	.377	90	.472	90	.566	90	.661
500	.095	1000	.189	1500	.284	2000	.379	2500	.474	3000	.568	3500	.663
10	.097	10	.191	10	.286	10	.381	10	.473	10	.570	10	.665
20	.098	20	.193	20	.288	20	.383	20	.477	20	.572	20	.667
30	.100	30	.195	30	.290	30	.384	30	.479	30	.574	30	.669
40	.102	40	.197	40	.292	40	.386	40	.481	40	.576	40	.670
50	.104	50	.199	50	.294	50	.388	50	.483	50	.578	50	.672
60	.106	60	.200	60	.295	60	.390	60	.485	60	.580	60	.674
70	.108	70	.202	70	.297	70	.392	70	.487	70	.581	70	.676
80	.110	80	.204	80	.299	80	.394	80	.489	80	.583	80	.678
90	.112	90	.206	90	.301	90	.396	90	.491	90	.585	90	.680

CHAPTER IX

HOW TO USE THE STADIA DIAGRAM

Formulas and the Diagram. The diagram for the reduction of stadia notes which accompanies this manual, is prepared specifically as a graphic solution at one operation of the approximation formulas:

$$D = (r + e) \cos^2 \alpha; \quad \ldots\ldots \quad (27)$$

and

$$h = (r + e) \sin \alpha \cos \alpha. \quad \ldots\ldots \quad (28)$$

But the diagram may also be used in ascertaining the values of $r \cos^2 \alpha$ and $r \sin \alpha \cos \alpha$ in the correct formulas (Eq. 17) and (18) and for the approximation of $(r+1) \cos^2 \alpha$ and $(r+1) \sin \alpha \cos \alpha$ in formulas (29) and (30). As the formulas (17) and (18) need only be used for sights to turning points and on surveys requiring more than ordinary precision, it would seem advisable to give preference to reduction tables whenever such approximation formulas as (27) and (28), or (29) and (30) will not serve.

To Use the Diagram: Follow the angle ray which corresponds to the angle α of elevation or depression, to its intersection with the curved line which corresponds to the value $(r+e)$ in formulas (27) and (28). Holding a needle point at the intersection thus determined read off by the aid of the vertical lines the horizontal distance D, that is $(r+e) \cos^2 \alpha$ and by the aid of the horizontal lines the difference in elevation h, that is $(r+e) \sin \alpha \cos \alpha$.

Or make the more convenient determination sufficiently close in all ordinary cases, by entering the diagram with $(r+1)$ instead of $(r+e)$.

Whenever the use of the approximation formulæ are permissible, as in the determination of topography, the diagram gives, at once, the distance and the difference in elevation, for any rod-readings and any vertical angles within their scope. Distance should be read to the nearest foot and difference in elevation to the nearest tenth of a foot.

When points are located by the intersection of sights from two instrument stations, the horizontal distances from each of these two stations are scaled from the map. The diagram is now entered with each of these distances and needle points are placed at the intersections of these distances with the corresponding angle rays of the measured angles of elevation or depression. If the same difference in elevation is not indicated by both needle points the mean value should be recorded.

The author, early in his experience on topographic surveys, constructed a diagram as here described based on the fundamental approximation formulæ (27) and (28) and has found the same a great convenience, fulfilling every requirement both as to minimizing mental effort, reducing the chance of error and insuring accuracy of results. It eliminates the undesirable features of many of the other diagrams at various times suggested for use, which do not give final results without additions or subtractions.

The explanatory notes for the use of the diagram are as follows:

STADIA DIAGRAM

For Instruments rated 1 to 100

Graphical Solution of the Approximation Formulas:

$$\begin{cases} D=(r+e)\cos^2\alpha \\ h=(r+e)\sin\alpha\cos\alpha \end{cases} \quad \text{or} \quad \begin{cases} D=(r+1)\cos^2\alpha \\ h=(r+1)\sin\alpha\cos\alpha \end{cases}$$

Where

r = reading on a vertical rod.
α = vertical angle.
D = horizontal distance.
h = difference in elevation.
e = instrument constant = the distance of the outside focal point of the object lens from the instrument axis.

Directions:

Follow the vertical angle ray to the curved line $(r+e)$ or $(r+1)$, as the case may be, and read D on the horizontal scale and h on the vertical scale.

NOTE.—The diagram can also be used to find the value of $r\cos^2\alpha$ and of $r\sin\alpha\cos\alpha$.

[redacted]

INDEX